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## CONTENTS

<i>Ogcocephalus darwini</i> , a New Batfish Endemic at the Galápagos Islands. By Carl L. Hubbs.....	161
Relation of Adult Pink Salmon Size to Time of Migration and Freshwater Survival. By Bernard Einar Skud.....	170
Additional Pleistocene Fishes from Kansas and Oklahoma. By C. Lovett Smith.....	176
A Description of a New Species of Stomatid from the North Pacific Ocean. By William Aron and Peter McCrery.....	180
An Experimental Study of the "Third Eye" of the Tuatara. By Robert C. Stebbins.....	183
Seasonal Variation in the Teeth of the Two-Lined Salamander. By Margaret McBride Stewart.....	190
Hybridization and Larval Development in <i>Rana palmipes</i> Spix. By E. Peter Volpe and Suzanne M. Harvey.....	197
Water Relationships in <i>Natrix sipedon</i> . By David Pettus.....	207
The Photic Responses and Water-approach Behavior of Hatchling Turtles. By Paul K. Anderson.....	211
HERPETOLOGICAL NOTES	
Body measurements of <i>Scaphiopus holbrooki</i> . By Paul G. Pearson.....	215
The water absorption response of an anuran. By W. T. Stille.....	217
A collection of amphibians and reptiles from Japan. By Donald R. Alexander and Richard A. Diener.....	218
The winter activities of <i>Rana clamitans</i> tadpoles. By Lowell L. Getts.....	219
A northern record for the Pacific ridley, <i>Lepidochelys olivacea</i> . By Warren J. Houck and James G. Joseph.....	219
Record and measurements of a leatherback turtle from the Gulf of Maine. By Carlton Roy and Christopher W. Coates.....	220
Longevity of snakes in the United States as of January 1, 1958. By Charles E. Shaw.....	221
Inducted oviposition in <i>Batrachoseps attenuatus</i> , and incubation of eggs. By Paul K. Anderson.....	221
Irruption of young <i>Batrachoseps attenuatus</i> . By Chapman Grant.....	222
A nocturnal tendency in <i>Phrynosoma platyrhinos</i> . By Robert Wesley Harris.....	222
A first record for <i>Trimorphodon lambda</i> in New Mexico. By Frederick R. Gehlbach.....	222
Mating behavior in the treefrog, <i>Hyla versicolor</i> . By Murray J. Littlejohn.....	222
Bullfrog food and growth at the San Joaquin Experimental Range, California. By Nathan W. Cohen and Walter E. Howard.....	223
ICHTHYOLOGICAL NOTES	
Size distribution of fishes in a Texas estuary. By George K. Reid and Hinton D. Hoese.....	225
Western North Atlantic records of <i>Beryx splendens</i> Lowe and <i>B. decodactylus</i> Cuvier and Valenciennes. By Leslie W. Scott.....	231
High salinity mortality of desert pupfish, <i>Cyprinodon macularius</i> . By George W. Barlow.....	231
A concentration of the ratfish, <i>Hydrolagus collettii</i> , Cape Arago, Oregon. By Harry G. M. Jopson.....	232
Record of a hatchery-reared rainbow trout, <i>Salmo gairdneri</i> Gairdneri, with three pelvic fins. By Galen H. Maxfield.....	232
Mouth size and food size in young rainbow trout, <i>Salmo gairdneri</i> . By G. F. Hartman.....	233
A summer silence of sea robins, <i>Prionotus</i> spp. By James M. Moulton.....	234
A case of poisoning by the lion fish, <i>Pterois volitans</i> . By Carleton Roy and Christopher W. Coates.....	235
A Panamanian gobiid fish, <i>Microgobius miraflorensis</i> , from western México, with taxonomic and ecologic notes. By Robert Kush Miller.....	235
Distribution of the Atlantic bigeye tuna, <i>Thunnus obesus</i> , in the western North Atlantic and the Caribbean Sea. By Frank J. Mather, III, and Robert H. Gibbs, Jr.....	237
<i>Gambusia senilis</i> from the Devil's River, Texas, an addition to the fish fauna of the United States. By Clark Hubbs.....	239
Hermaphroditism in the cutthroat trout. By Norman G. Benson.....	239
Reviews and Comments.....	240
Editorial Notes and News.....	244

NEXT MEETING: The American Society of Ichthyologists and Herpetologists will meet on the campus of Indiana University, Bloomington, Indiana, from Aug. 24 to Aug. 28, 1958, inclusive. The sessions will be held in conjunction with the meetings of the American Institute of Biological Sciences.

## *Ogcocephalus darwini*, a New Batfish Endemic at the Galápagos Islands<sup>1</sup>

CARL L. HUBBS

ONE HUNDRED years ago the epochal theory of evolution was announced by Darwin and by Wallace. Among the phenomena that led each to the conclusion that species are naturally derived, the phenomenon of endemism on islands was particularly indicative. Ever since, the analysis of endemism has played an important role in the development and clarification of evolutionary concepts. In view of the centennial celebrations honoring the memory of Darwin and Wallace, and in view of the circumstance that Darwin's most significant observations on insular endemism were made at the Galápagos Islands (Archipiélago de Colón), it seems appropriate to associate Darwin's name with another Galápagos endemic, a new batfish that I have had under study for some years.

### *Ogcocephalus darwini*, sp. nov.

Pl. I, Fig. 1; Pl. II, Fig. 1; Pl. III, Fig. 1; Pl. IV, Figs. 1-2; Pl. V

*Ogcocephalus* [species].—Lundy, 1956: 468-9, 4 Figs. (popular account of capture, appearance, and habits of specimen SIO 56-60).

The only published account of this species, except for a number of newspaper stories (none carrying a specific name), is that of Lundy.

### RELATIONSHIPS

This new fish is a member of the cosmopolitan family Ogcocephalidae (the batfishes), which is one of the terminal groups of the highly modified order Pediculati (Lophiiformes). Within this family it is referable to the Ogcocephalinae (Jordan and Evermann, 1898: 2736), which seems to take its place among the growing list of fish groups recognized as characteristic of the warm waters of the New World, both Atlantic and Pacific. Whether the group deserves subfamily rank, and whether any Old World genera such as *Malthopsis* Alcock are referable to this group, are problems in need of consideration. With two exceptions, the hitherto-known American ogcocephalines are

members of the West Indian fauna, and all of the Atlantic forms are referred to the type genus *Ogcocephalus* Fischer (spelling often emended to *Oncocephalus*).

The new species is obviously distinct from any of the Atlantic forms, as described by Jordan and Evermann (1898: 2736-2738; 1900: 3313, pl. 392), by de Miranda Ribeiro (1915: 1-4 [pagination separate for each family; would be pp. 645-8 if serially numbered, not including introductory matter or plates], 1 pl.), and by Hildebrand (in Longley and Hildebrand, 1940: 283-5, fig. 28; 1941: 311-315, pl. 33, fig. 2). It is quite different in coloration and has 14 to 16 pectoral rays, rather than 11 or 13.

*Ogcocephalus darwini* is obviously not closely related to either of the two previously known Pacific American ogcocephalines, but may be regarded as an insular derivative, or relict representative, of *O. porrectus* Garman. It is quite unlike *Zalieutes elater* (Jordan and Gilbert) in its less expanded disk, strongly projecting snout, more numerous pectoral rays, smaller tubercles, very different coloration, etc. (see Kumada, 1937: 62, pl. 102). Whether the generic separation of *elater* from *Ogcocephalus* will be continued is very dubious, but is a proper subject for critical consideration, such as Margaret G. Bradbury at Stanford University will afford in her revision of the group. *Z. elater* is generally recorded as ranging from México to Panamá, but it occurs as far north as off Pt. Conception, California, where two specimens were caught in halibut nets in January, 1945 (Irwin, 1945). One of these is here figured (Pl. IV, Fig. 3). Other specimens have been taken in southern California.

The obvious geminate of *Ogcocephalus darwini* is *O. porrectus*, described by Garman (1889: 86-8) from Albatross Station 3368, south of the Gulf of Panamá, in the vicinity of Cabo Corrientes, Colombia, at Lat. 05° 32' 45" N., Long. 86° 54' 30" W. on a rocky bottom at a depth of 66 fathoms, where the water temperature was 58.4° F. (surface water temperature, 82°). The 4 syntypes, 49, 56, 115.5, and 147 mm. in standard length, in the

<sup>1</sup> Contributions from the Scripps Institution of Oceanography, New Series

Museum of Comparative Zoology, Harvard University, were taken in a small beam-trawl on February 28, 1891 (I have selected the 147-mm. specimen, shown on Plates I-III, as lectoholotype). No other specimens seem to have been obtained and the only subsequent listings of the species appear to be that of Fowler (1944: 527), as *Oncocephalus porrectus*, and that of Lundy (1956: 469), who gave the locality as "the depths of Panama Bay." All specimens in the United States

humeral spot and the anterior part of the rather faint stripes along the sides of the urosome; or, the stripes of *darwini* could have become disrupted and modified to produce the pattern of *porrectus*. Whether *darwini* is an insular derivative of *porrectus* or is the relict of a type ancestral to *porrectus*, or to both species, is not apparent.

In numerous minor respects, *O. darwini* differs from *porrectus* (Table I, Fig. 1, Pls. I-III). The tabulated comparison constitutes

TABLE I

COMPARISON OF THE TWO RELATED PACIFIC SPECIES OF *Ogocephalus*

Based on a direct comparison of types. The capital letters refer to graphs in Figure 1.

Character	<i>O. darwini</i>	<i>O. porrectus</i>
Tubercles at comparable sizes	Much smaller, flatter, less spinous; each much broader than high	Much larger, more elevated, more spinous; each much higher than broad
Sculpture below	Very fine	Rather coarse
Main dark color marks	Pair of dark stripes, on posterior half of disk and backward, very much longer than snout	Pair of blotches, near middle of disk, about as long as snout
Other dark markings on disk and tail	Hardly a trace of markings other than the main stripes	Irregular striping and blotching on side of tail; weak blotches on disk
General color tone	Dark	Light
Proportional size of disk region at comparable sizes (C, G, H)	Smaller	Larger
Body and peduncle at comparable sizes (A, B)	Deeper	Slenderer
Shape of disk and snout	More rounded at sides and tip	More sharply triangular
Snout (D, E)	Less elevated, and shorter	More elevated, and longer
Distance between pelvic axils (F)	Greater	Less
Body behind pectoral expansion (I)	Much wider	Slenderer
Average length of fins (Table II)	Greater	Less
Dorsal rays <sup>1</sup> (Table III)	3, seldom 2 or 4	2 or 3
Pectoral rays (Table III)	14 to 16, usually 15	14

<sup>1</sup> Counting last two elements as one ray.

National Museum from the Pacific identified as *Ogocephalus* proved on examination in 1956 to be referable rather to the Halieutinae.

In a number of respects, in addition to the approximated ranges, *O. darwini* discloses relationship with *O. porrectus*. The pectoral rays are relatively numerous (14 to 16 in *darwini*, 14 in *porrectus*). The general proportions, body build, head physiognomy, and snout production are rather similar. The pattern of the bony tubercles is virtually identical. The double-striped pattern of *darwini* could be derived from the pattern of *porrectus* by intensification and fusion of the

a diagnosis of the new species. Most of the differences lie in morphometry and in texture, in which respects *porrectus*, with the specific differences overshadowing the ontogenetic (see plates), accentuates and retains juvenile features. This is a point of evolutionary interest, because it is commonly the insular representatives that emphasize juvenile features. The juvenility of *porrectus* may be related to its rather deep-water habitat.

## DATA ON TYPE SPECIMENS

The holotype, in Scripps Institution of Oceanography, of the University of California, La Jolla (No. H51-214), an adult 135

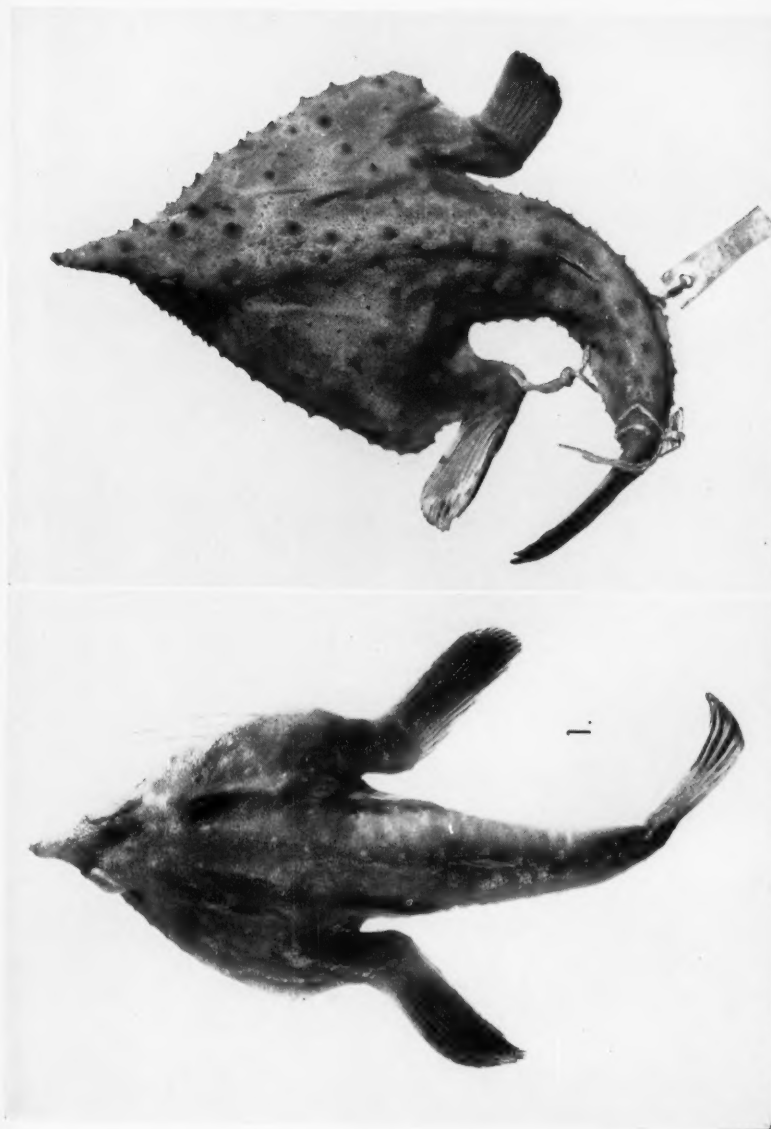
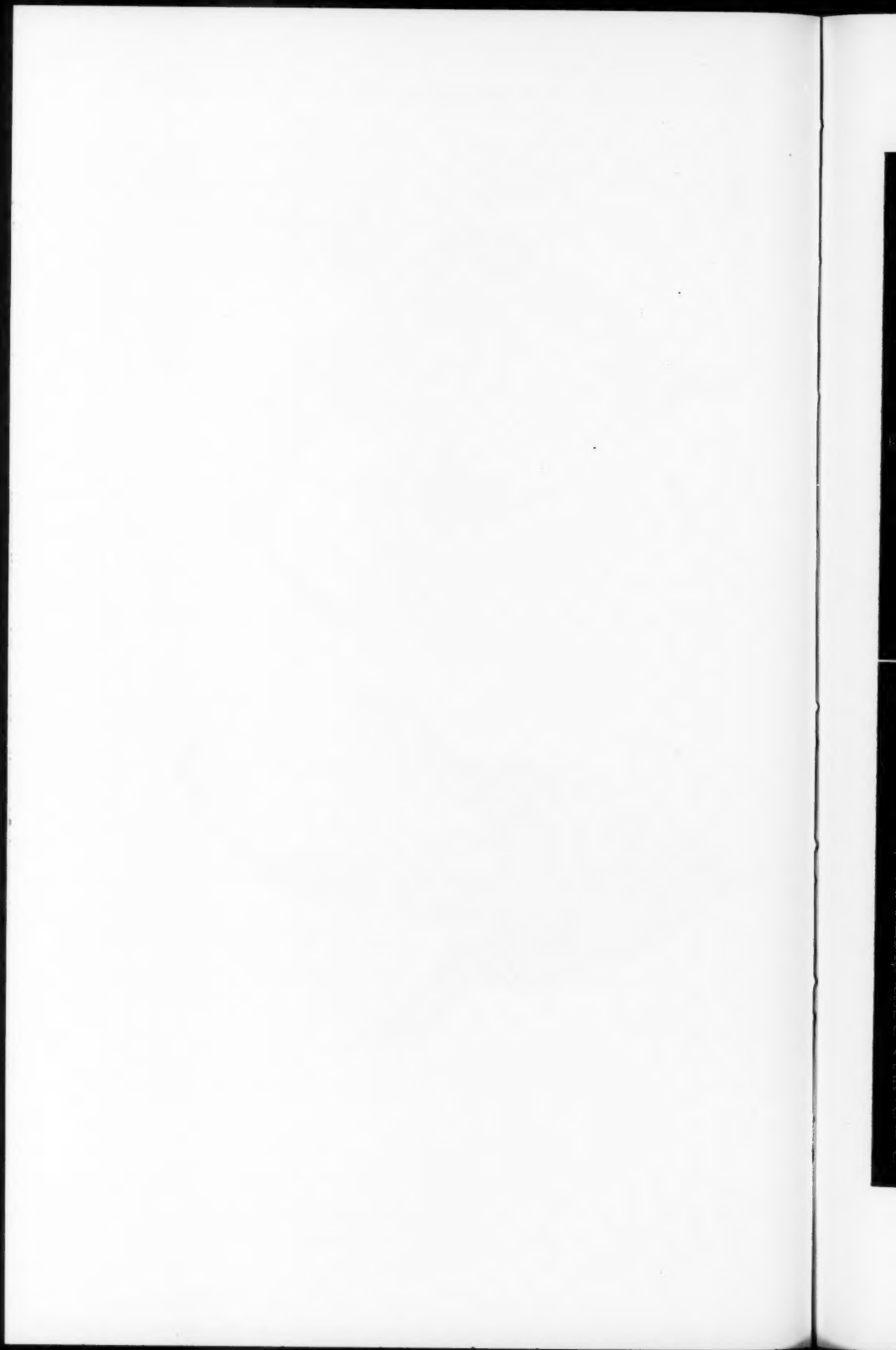


Plate I. Holotypes of *Ogcocephalus darwini* (Fig. 1) and of *O. porrectus* (Fig. 2) in dorsal view. Standard lengths respectively 135 and 147 mm. For Plates I–III the photographs of *O. darwini* were taken by James E. Ruppert of Scripps Institution of Oceanography, University of California, La Jolla; those of *O. porrectus*, by Frank White of Harvard University.



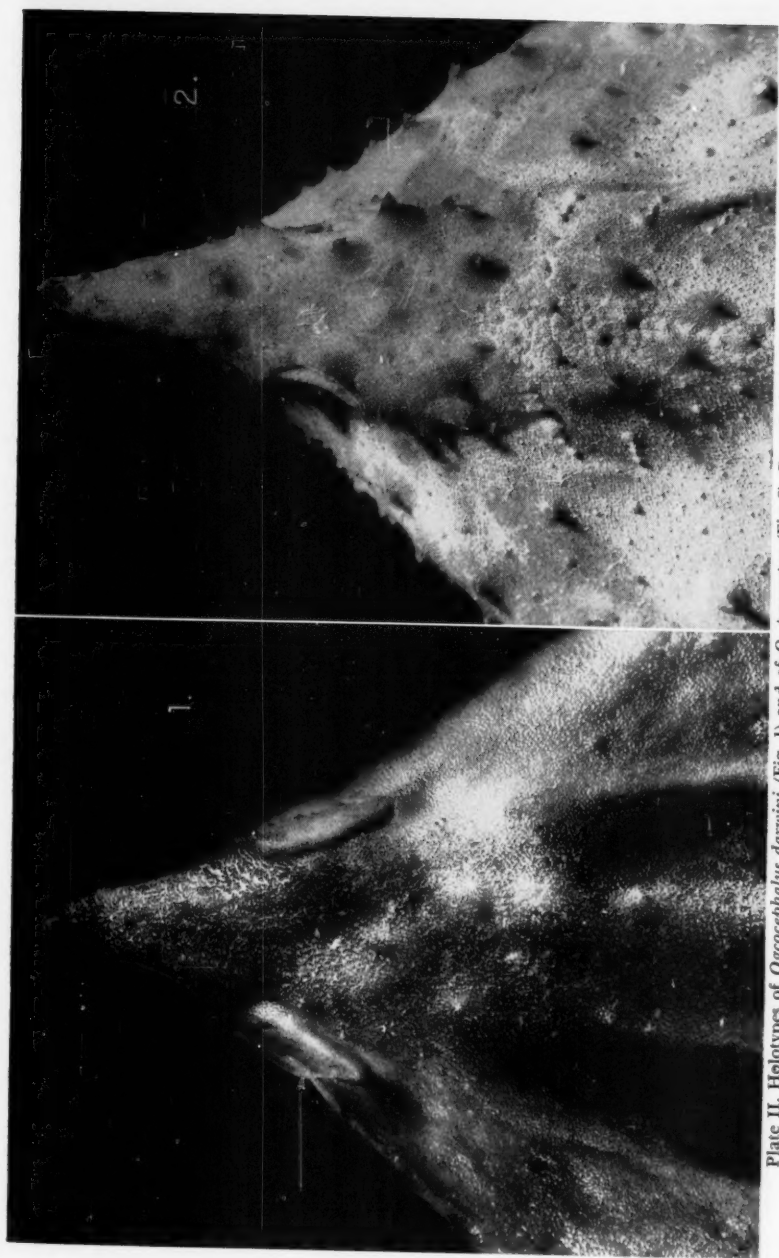


Plate II. Holotypes of *Ogcocerphalus darwini* (Fig. 1) and of *O. porrectus* (Fig. 2). Dorsal views of anterior parts, magnified.



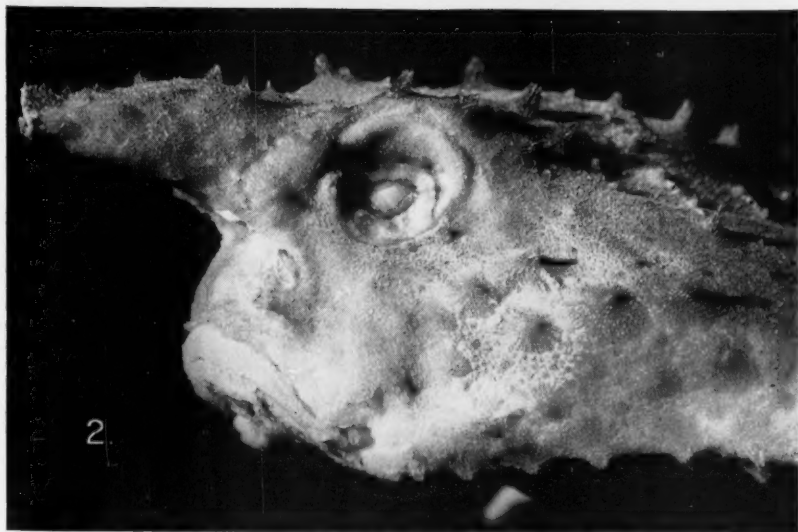


Plate III. Holotypes of *Ogocephalus darwini* (Fig. 1) and of *O. porrectus* (Fig. 2). Lateral and very slightly anterior views of head region.

I

H

G

F

E

D

C

B

A

E  
and

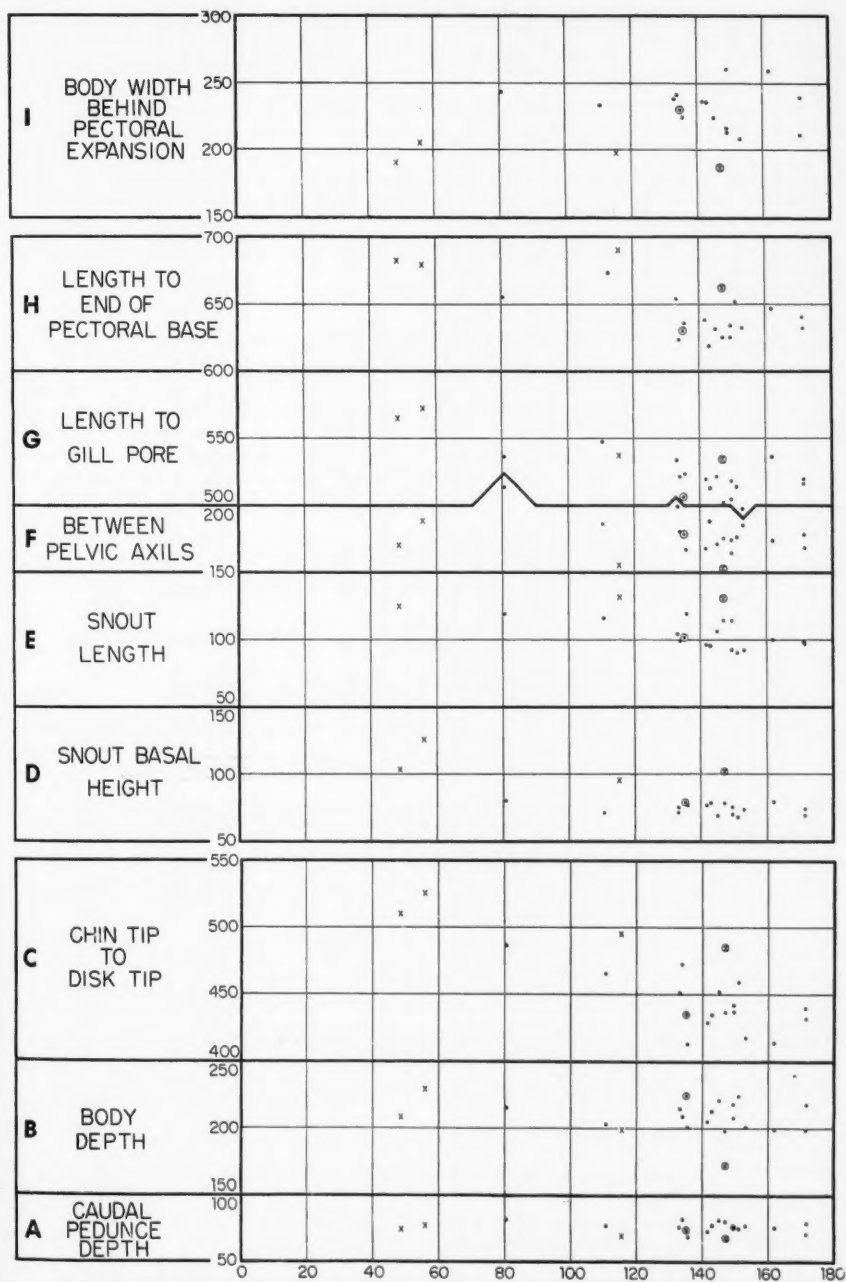


Fig. 1. Distinctive proportional measurements of the types of *Ogcocephalus darwini* (dots) and of *O. porrectus* (crosses). Symbols for the holotypes are encircled. Data from Table II.

TABLE II  
PROPORTIONAL MEASUREMENTS OF THE TWO RELATED PACIFIC SPECIES OF *Ogcocephalus*

The measurements are expressed in thousandths of the standard length, those for the *O. darwini* types in italics and those for the *O. porrectus* types in boldface; in sequence of standard length. The capital letters in parenthesis designate characters graphed in Figure 1. P<sub>1</sub> = pectoral fin.

Standard length, mm.	To center of anus	To end P <sub>1</sub> base (H)	Length to gill pore (G)	Chin tip to disk tip (C)	D origin to C base	A origin to C base	Caudal fin length	Pectoral fin length	Pelvic fin length	Between pelvic axils (F)	Body depth (B) <sup>1</sup>	C peduncle depth (A) <sup>1</sup>	Width behind P <sub>1</sub> fins (I) <sup>1</sup>	Between gill pores	Gill pore to elbow	Disk width (expanded) (J)	Snout plus orbit	Snout length (E)	Snout depth (middle) <sup>2</sup>	Snout depth (base) (D) <sup>1</sup>	Snout width (base) <sup>3</sup>	Skull prominence width <sup>4</sup>	Interorbital width	Cornea length	Cornea to preorbital	Cornea to nostril	Upper jaw length	Mouth width (over all)	Supraorbital rim to angle of mandible
48.7	616	682	565	510	316	173	275	211	170	170	208	74	190	270	131	615	209	125	95	103	79	149	64	79	70	31	98	121	198
56	670	679	572	535	343	163	260	232	192	188	230	77	205	320	126	613	211	126	27	125	81	155	65	78	70	26	94	130	200
80.6	654	655	536	486	343	176	293	256	191	213	215	81	243	305	126	556	208	110	40	80	77	144	67	65	65	20	89	115	189
110.6	649	673	548	465	343	167	293	288	190	181	203	77	233	281	156	495	192	116	41	71	74	149	61	57	61	35	98	120	173
115.5	628	690	537	495	345	177	235	267	177	166	199	69	198	289	165	550	194	132	42	96	78	127	59	66	71	27	93	118	192
133	631	654	534	472	340	169	247	283	180	199	215	76	238	308	143	567	185	104	36	71	71	134	59	66	66	26	88	116	180
133.8	611	623	521	472	347	180	236	256	174	180	209	82	241	296	132	573	187	99	45	75	82	134	64	66	68	28	87	117	181
135	624	630	506	435	346	167	285	285	206	178	225	74	230	288	121	523	180	102	36	77	76	147	65	65	64	27	88	113	184
135.6	625	636	523	413	368	191	251	273	179	167	201	69	224	288	141	533	202	119	46	77	70	131	64	66	61	21	85	115	170
141.7	627	638	519	429	332	158	245	246	168	168	205	73	236	279	138	481	189	96	39	77	82	130	70	74	59	18	87	111	190
143	621	619	512	435	328	183	274	267	189	187	213	78	236	302	120	557	193	95	36	78	73	122	67	66	60	26	87	114	170
145	568	631	521	452	335	166	247	247	172	171	221	81	187	290	146	644	199	131	48	102	76	121	62	54	64	28	90	116	166
147.1	590	625	504	442	341	167	241	230	159	153	172	68	187	269	146	644	199	131	48	102	76	121	62	54	64	28	90	116	166
147.3	631	625	504	442	346	158	238	220	177	174	218	76	216	303	143	538	182	97	33	70	73	127	57	71	58	21	89	114	175
149.3	631	625	518	437	324	175	269	266	195	165	208	76	213	350	144	473	199	114	44	75	74	174	65	64	58	25	84	114	175
149.5	625	634	518	459	329	157	260	255	168	176	224	75	260	302	145	523	172	90	31	68	71	124	58	59	68	28	91	110	187
151	642	652	513	478	316	133	248	275	188	185	201	77	208	292	145	523	172	92	37	73	77	150	62	65	59	25	88	107	177
153	620	632	497	418	323	157	244	233	158	173	199	71	211	290	134	470	179	98	36	89	70	128	60	65	60	23	84	103	175
162	629	647	536	447	343	193	229	246	160	178	199	70	211	290	134	470	179	98	36	89	72	125	65	55	60	23	79	100	159
171.3	629	640	516	440	343	193	229	246	160	178	199	71	211	290	134	470	179	98	36	89	72	125	65	55	60	23	79	100	159
171.4	602	632	519	432	354	151	267	254	187	169	218	70	239	295	136	558	185	97	39	74	78	156	62	64	61	25	88	122	181

<sup>1</sup> Excluding major tubercles.

<sup>2</sup> 1.5 mm. added to replace missing spine.

<sup>3</sup> Holotype.

<sup>4</sup> Specimen considerably shrunken, but proportions scarcely altered.

<sup>5</sup> Specimen dried, but proportions listed, except disk width, little modified.

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mm. in standard length, shown on plates I-V, was collected by Robert Devine, Navigator of the Tuna Clipper CHICKEN o' THE SEA, on April 25, 1951 at Caleta Tagus (Tagus Cove), on Isla Isabela (Albemarle Island), Galápagos Islands (Archipiélago de Colón). This cove is located approximately at Lat. 00° 16.0' S., Long. 91° 22.5' W., as read from H. O. Chart 1798 (October, 1946). The collector reported that the specimen was taken at midnight by dip-net under light. The proportional measurements of the holotype are indicated in Table II and the ray counts (Table III) are all modal.

All other specimens examined are designated as paratypes, as they are all from the Galápagos Islands and are consistent in essential characters. The data follow, in sequence of the Collection Numbers as listed in the records of the Fish Collection at the Scripps Institution of Oceanography (for

H51-51.—Collected by Ernest Silva on the Tuna Clipper BERNADETTE in January or February, 1950, just outside Caleta Webb (Webb Cove) on Isla Isabela, which is at Lat. 00° 48' S., Long. 91° 26' W. It was found tangled in a Galápagos bait-net, near the bottom, and was preserved in rubbing alcohol. Illustrated on Plate IV, Figure 1. Length 80.6 mm.

H53-196.—Collected by "Mits" Hosaka on the Tuna Clipper SUN TRAVELER in late October, 1953, at Punta Mangle on Isla Fernandina (Narborough Island), which is approximately at Lat. 00° 27.0' S., Long. 91° 23.0' W. It was captured in a Galápagos bait-net at a depth of 2 fathoms, 50 yards offshore. Length 171.4 mm.

SIO 54-175.—Collected by Herman Hawkins on the Tuna Clipper LIBERTY BELL in June or July, 1954, at Caleta Tagus, Isla Isabela, which is at Lat. 00° 16.0' S., Long. 91° 22.3' W. The method of collection was not stated. This specimen was preserved in rubbing alcohol. Length 133 mm.

SIO 54-199.—Collected by Jay Plummer late in October, 1954, at Bahía Elizabeth, the near-shore position of which is roughly centered at Lat. 00° 36' N., Long. 91° 06' W. Length 162 mm.

TABLE III

FIN-RAY COUNTS IN TWO RELATED PACIFIC SPECIES OF *Ogcocephalus*

The last two elements in the dorsal and anal fins are counted as one ray.

Species	Dorsal Rays			Anal Rays		Unbranched C Rays			Branched C Rays			Total C Rays	Pectoral Rays			Pelvic Rays
	2	3	4	2	3	1	2	3	6	7	8	9	14	15	16	I, 5
<i>darwini</i> .....	1	15	1	1	16	1	14	2	2	14	1	17	7	25	2	34
<i>porrectus</i> .....	2	2		..	4	..	4		..	4	..	4	8	..	..	8

purpose of the record, borrowed specimens are included in the Scripps listing). The standard lengths are those obtained when the measurements were recently made for Table II.

H50-18.—Received from Peoples Cannery of San Diego; collected by Bob Grove of the Tuna Clipper WEST COAST about January 1, 1950, at Punta Moreno, Isla Isabela, which is approximately at Lat. 00° 41' S., Long. 91° 20' W. It was taken in a "Galápagos bait-net" (see below, under Range and Habitat), while seining for "herring" in shallow water near shore. Length 135.6 mm.

H50-19.—Collected by John Furuya on the Tuna Clipper SUN PADRE and received from him on February 17, 1950, when the ship returned to San Diego; taken in Bahía Elizabeth on the west side of Isla Isabela, in a Galápagos bait-net near shore in shallow water. The collection comprised three adult specimens which were studied and photographed. One was returned to the collector in 1951. The other two have been misplaced.

H50-132.—Collected by Jack Buchanan on the Tuna Clipper SUN QUEEN during the last week of April, 1950, in Bahía Elizabeth, Isla Isabela, in a Galápagos bait-net at a depth of about 3 fathoms. Length 151 mm.

SIO 55-16.—Collected by Lars Sunde, Chief Engineer of the Tuna Clipper CAPE FALCON about January 1, 1955, at Punta Moreno, Isla Isabela (see H50-18 for position). It was taken in a Galápagos bait-net close to the beach in a depth not over 5 fathoms. Length 153 mm.

SIO 56-60.—Collected by M. M. Cardozo on the Tuna Clipper MARY E. PETRICK in March or early April, 1956, on Isla Isabela. It was picked by hand from a Galápagos bait-net, near the bottom, by Mr. Cardozo while diving to tend the net. The net was set near shore at a depth of about 2.5 to 3.0 fathoms. The capture of this specimen has been described by Lundy (1956). It was preserved in rubbing alcohol. Length 149.5 mm.

SIO 57-20.—Collected September 15, 1950, at Bahía Banks, Isla Isabela (near the north end of the west shore, which is at approximately Lat. 00° 01' S., Long. 91° 29' W.); received in the University of Washington Fish Collection from Walter J. Eyerdam. Specimen considerably shrunken. Length 141.7 mm.

SIO 57-22 (Stanford University No. 17112).—Collected by William B. Morrel on the Tuna Clipper SANTA HELENA, on July 16, 1951, at the Galápagos Islands (exact location not recorded). The collector stated that he took the specimen by dip-net under light (Anita B. Daugherty, personal communication). Length 133.8 mm.

SIO 57-23 (Stanford University No. 14977).—Collected by William L. Luttrell, Engineer on the Purse Seiner *SANTA HELENA* (later converted to a Tuna Clipper bait-boat), about October or November, 1948, at Bahía Banks (see SIO 57-20), Isla Isabela. The specimen was caught in a tunanet (purse-seine), of a type that was not fishing deeper than about 42 fathoms. It was first reported to have been taken near the surface where the depth is at least several hundred fathoms, but the collector recently told Anita B. Daugherty that the original information may have been incorrect, as the bottom is very irregular and drops off very abruptly. He now thinks it possible that the batfish was picked off the bottom. Length 171.3 mm.

SIO 57-24 (Stanford University No. 16901).—Collected by fishermen in 1948 aboard the Purse Seiner *COLUMBIA* at the Galápagos Islands, probably at Bahía Banks (see SIO 57-20). The net used was fishing for tuna to a depth of 20-25 fathoms at most, over "fairly deep" water. The crew reported to Anita B. Daugherty that on this trip they picked up about a dozen batfish while purse-seining for tuna. They brought back two specimens, dried, and gave the one here listed to Miss Daugherty. Length 145 mm. (slight allowance made for shrinkage).

SIO 57-111 (in collection of California State Polytechnic College).—Collected by fishermen on a tuna clipper on December 24, 1949, in Caleta Webb (Webb Cove), Isla Isabela (see H51-51 for position). It was taken in a Galápagos bait-net. The specimen was originally preserved in rubbing alcohol. Length 110.6 mm.

SIO 57-166.—Collected at the Galápagos Islands some years ago by fishermen on a tuna boat; probably brought in by William L. Luttrell, Engineer on the Purse Seiner *SANTA HELENA* (further data lost); received from Anita B. Daugherty of the California State Fisheries Laboratory. Length 149.3 mm.

SIO 57-167 (in collection of Allan Hancock Foundation, University of Southern California).—Dredged on December 13, 1934, on the Allan Hancock Pacific Expedition 1935, Galápagos Islands, at Station 345-35, between Daphne and Seymour islands at Lat.  $00^{\circ} 24' 50''$  S., Long.  $90^{\circ} 21' 40''$  W., at a depth of 30 fathoms. It was kept alive until January 2, 1935, and was obviously preserved in formalin. Length 147.1 mm.

SIO 58-39.—Collected by Joe Freer on the Tuna Clipper *CHICKEN O' THE SEA* in the latter part of 1954, on either the west side of Isla Isabela (Albemarle Island) or east side of Isla Fernandina (Narborough Island). Length 143 mm.

All specimens, except as indicated above, were brought to San Diego or San Pedro frozen, then preserved briefly in formalin. The specimens kept at Scripps Institution are in 40% isopropyl alcohol and are less shrunken than those in other collections, which are in ethyl alcohol.

#### RANGE AND HABITAT

All known specimens were taken about the Galápagos Islands, to which the species is apparently confined. It takes its place among the numerous endemics of these islands.

Most of the records are from the west shore of Isla Isabela (Albemarle Island), probably because this is an area where the American tuna fishermen commonly fish and "make bait." One specimen came from the east shore of Isla Fernandina (Narborough Island), facing Isabela. It is possible that the species is commonest in the region between islas Isabela and Fernandina, where conditions are affected by the Humboldt (Perú) Current and by upwelling. One specimen was dredged between Daphne and Seymour islands, north of Isla Santa Cruz or Chávez (Indefatigable Island).

Most of the known specimens were taken in "Galápagos bait-nets," which are hauled near shore over rough rocky bottom, with the aid of a diver to free the lead-line when snagged (these nets are hauled to obtain live bait to be used as chum in the operation of the bait-boats of the tuna-clipper fleet of San Diego). Some of the specimens, however, are reported to have been dip-netted under light or to have been taken in the nets of the purse-seine fleet (of San Pedro). It is therefore highly probable that some individuals move toward the surface, even out over deep water where very close to shore, as in Bahía Banks (Banks Bay) near the north end of Isla Isabela. We are finding that a considerable number of fishes seemingly adapted to bottom existence more or less regularly move toward the surface, especially at night.

#### METHODS OF COUNTING AND MEASURING

Since the batfishes are so peculiar, the methods here used in counting and measuring need specification. The vertebrae, counted by X-ray, include the hypural. The rays in the fins are often readily counted by noting the free tips, by sighting the body of the rays directly or by transmitted light, by feeling the separation by a sharp instrument, or by X-ray; but often, in any fin, the rays may be so obscured as to require partial dissection for a secure count. The last two elements in the dorsal and in the anal fin are enumerated as one ray, in line with the only single, simple criterion. The gills were counted by dissection in one paratype.

The standard length is measured by pressing the point of the dividers or calipers backward against a superficial swelling over the expanded bases of the middle caudal rays (Pl. IV, Fig. 2). The same method determines the end point for the distance from the origin of the dorsal and of the anal fin to

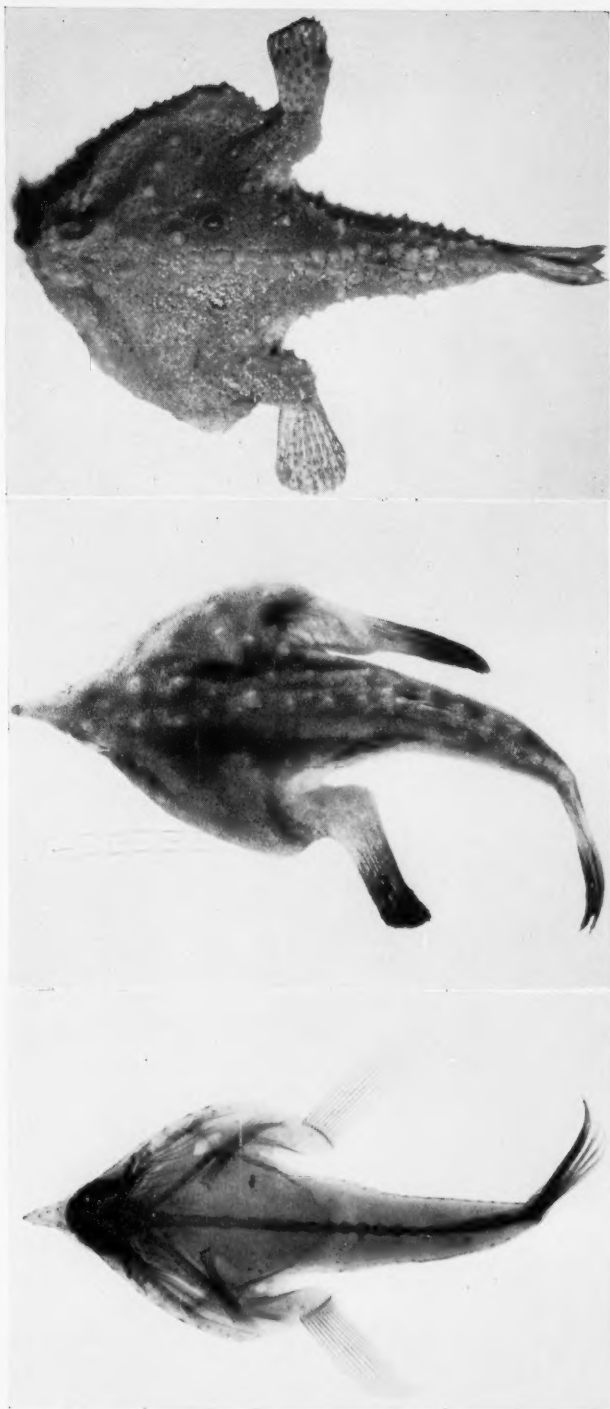


Plate IV. Pacific Species of Ogcocephalinae.

Fig. 1. *Ogcocephalus darwini*, smallest paratype (H51-51), 80.6 mm. in standard length. Photograph by Scripps Institution of Oceanography.

Fig. 2. *Ogcocephalus darwini*, X-ray photograph of holotype, by Nobuo Egami, to show skeletal features. Print by Scripps Institution of Oceanography.

Fig. 3. *Zalieutes elater*, from off Pt. Conception, California. Photograph furnished by Margaret C. Irwin, when with the Santa Barbara Museum of Natural History.

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the caudal base. The origin of the dorsal and of the anal fin is the front base of the first ray, which may bear some fine prickles like those of the general integument (a hard sloping edge precedes the base of the first anal ray). Unless otherwise stated, the initial point of all measurements is the extreme tip of the snout, including the terminal spine or spines. In other measurements the major tubercles are excluded. In measuring "chin tip to disk tip" the end point is the rear of the last major tubercle near the outer angle of the disk (the underlying bony terminus is not precisely detectable). "Caudal fin length" is measured from the caudal base, determined as indicated above, to the extreme tip of a median ray. "Pectoral fin length" is from the posterior end of the base (near the "elbow") to the farthest tip. "Pelvic fin length" is from the middle of the base (determined as for the caudal fin) to the farthest tip. "Between pelvic axils" is taken across the hidden bases when the fins are spread apart. "Width behind  $P_1$  [pectoral] fins" is taken where the body margin reaches a maximum curvature near the solid part of the urosome, behind the disk (a good measurement, though somewhat subjective).

Measurements involving the gill pore are to the nearest free margin of the pore. "Disk width (expanded)" varies greatly with preservation and with force used in expansion. Snout and orbit measurements are from the bony rim. "Skull prominence width" is taken where the prominence is widest, to points of greatest concavity on each side. "Interorbital width" is measured with points pressed tight. "Cornea" is that portion of the eye covering that is free of prickles. "Upper jaw length" is to the concealed rear tip.

#### DESCRIPTION

**BODY FORM.**—When fully expanded the disk approximates an equilateral triangle, with the width about equal to the length of either side. When the disk is contracted, with the pectoral peduncle appressed against the side of the body, the width is approximately two-thirds the length of either side. Anteriorly, the contour of each side is rather strongly concave, due to the projection of the long snout, whereas posteriorly each side is somewhat convex, more so than in *O. porrectus*. Behind the gill pore a broadly U-shaped indentation largely separates the pectoral peduncle from the sides of the trunk. The occipital region is rather markedly elevated into a somewhat dome-shaped

prominence. The front of the head is also much elevated, so that in anterior view the region of the eyes and mouth is rather rectangular, about half again as high as wide. The trunk and tail region behind the disk is relatively thick, but also elongated. The width is about one-third greater than the depth. The outer-ventral edge is moderately ridged from the pectoral axil to the caudal base just below the end of the lateral line, and the intervening ventral surface is rather flat. The sides are subvertical and moderately convex, with a slight groove along the lateral line. Anteriorly, the dorsal surface is strongly arched and somewhat keeled, but posteriorly is quite flat. In lateral view the contours are considerably constricted along the caudal peduncle. Otherwise the contours taper rather evenly toward the caudal fin.

**HEAD FORM.**—The subconical snout projects beyond the orbit a distance about equal to that between the orbit and the occiput. The direction is essentially horizontal, but is variable, as are also the length and the contours of the snout. In general, the snout is about as high as wide. The nostrils are near the outer edge of the fleshy area over the premaxillary spines. The slitlike posterior nostrils lie close to the downward-curved bony rostral ridge that ends above the middle of the mouth. The smaller, nearly round anterior nostril is bordered by a slight fleshy rim. The spacious orbit is much larger than the clear, oblique cornea. The rest of the eye surface is covered by a fine shagreen. The eye is directed outward and slightly downward. The interorbital space is somewhat depressed as a shallow cavity, which is obliterated above the front of the orbit where the projecting snout takes shape. The width of the broad and flat suborbital region approximates the length of the cornea.

**ILLICIUM.**—The illicium (Pl. V) fits snugly into the anterior angle of a deep and rather acutely subtriangular fossa, the membrane of which is largely devoid of prickles where in contact with the head of the illicium, and also on its subvertical posterior wall. When the illicium is at rest, the short thick stem fills the deep, oblique part of the cavity, and ends ventrally in the esca, comprising a median whitish fleshy lobe and, on either side, a more prominent rounded lobe. These lateral lobes diverge backward, and are jointly separated from the broadly triangular and flatter anterior lobe by a thick and short

neck. In anteroventral view the esca is approximately as long as the pupil.

**MOUTH.**—As seen from below, the mouth is approximately semicircular. The lower jaw is included, and the upper lip is essentially in line with the subvertical front of the head below the base of the snout. The front of the mouth is distant from the illicium about the length of the cornea. The concealed extreme tip of the upper jaw lies on a vertical passing between pupil and rear of orbit. The gape in side view is very slightly oblique.

**TEETH.**—The fine, needle-like teeth form villiform bands on the jaws, vomer, palatine, and tongue. The weakly curved and rather broad premaxillary band is obliquely truncated laterally. The narrower mandibular band is somewhat more curved and tapers to a point laterally. The vomerine patch is larger than the pupil. It is broadest close to its convex anterior edge and tapers considerably to its squarely truncated rear. Each palatine patch is much smaller. Most of the broad upper surface of the tongue is covered by a flat dentate area, which is incompletely divided by a lengthwise groove.

**SENSORY LINE.**—Just behind the vertical through the anus, over a space about equal to that of the eye, the lateral line takes an abrupt descent. Posteriorly, the lateral line runs a little below the middle of the side. In the holotype, the pores in the lateral line number 29–28, counting from a double pore at the origin of the horizontal line just behind the eye to the pore at the caudal base. Each pore is protected by a pair of spiny points that arch so as to nearly meet above and below, as described by Garman for *O. porrectus*. Similar structures appear along the infraorbital canal, which is angulated downward to near the corner of the mouth, and also appear along the preoperculomandibular line, which runs just below the edge of the disk and then forward around the chin, where the spiny protections for the pores are especially prominent. At the tip of the chin, in advance of the main series, two strongly protected pores form a supplementary crosswise series. Behind the mouth are two separated, protected pores, derived respectively from the infraorbital and the preoperculomandibular series. There are other pores of this type along the rostral fold, above the upper lip anteriorly. The pores of the supraorbital series are indistinct, except for three or four that are subvertically aligned just in ad-

vance of the orbit. A transverse commissure crosses the midline just in advance of the occiput. No fleshy filaments are apparent.

**SHAGREEN AND TUBERCLES.**—Except about the illicium, on the fossa of the gill pore, and on the lips, the external surfaces of the head and body are covered by a very fine prickly shagreen. This velvety surface extends rather uniformly out over most of the pelvic fin, and to a variable extent over the anal and dorsal. There is also a covering over most of the surface of each pectoral and caudal ray, where the rays are exposed when folded together.

The tubercles, unlike those of *O. porrectus*, have a very low central point, that is often hardly evident. The total height of each tubercle is very much less than the diameter. The tubercles are covered by spiny points like those on the intervening integument. Though somewhat smaller and very much flatter and less elevated and spinous, the tubercles follow essentially the same pattern as in *O. porrectus*. In advance of the eye, medially, there is a rather prominent and sharp tubercle at the very edge of the orbit, and, a little downward and forward, a poorly developed one. Along the upper and posterior edge of the orbit are two tubercles. In the occipital region four large bucklers form a rectangular pattern, with two in advance of the occiput and two just behind. Between these and the dorsal fin there are a number of bucklers, with a few quite large ones along the midline (these are somewhat paired transversely not far behind the occiput), and there is a strong pair at the front of the dorsal fin. The series is doubled along and immediately behind the dorsal fin, but tends to become single on top of the caudal peduncle. Strong tubercles, more or less biserial, arm the hard edge of the disk. Between these and the dorsal series a number of other tubercles are rather widely scattered. Smaller ones occur along the cheek and snout. A double row flanks the lateral line posteriorly, with a strong tendency toward the alignment of a pair opposite each pore. On the upper part of the tail region, a few others of variable size are scattered between the dorsal and the lateral-line series.

**GILL STRUCTURES AND OTHER INTERNAL CHARACTERS.**—The gill pores are oblique slits only about as long as the pupil. Dissection of a paratype discloses  $2\frac{1}{2}$  gills, as in other species of the genus. There is no gas-bladder, and no pyloric caeca. The vagus

C. L. HUBBS—NEW BATFISH ENDEMIC AT GALAPAGOS



Plate V. Holotype of *Ogcocephalus darwini*. Anteroventral view, to show illicium and adjacent region. Photograph by Scripps Institution of Oceanography.

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Other internal characters are shown by X-ray photographs (that of the holotype is reproduced as Plate IV, figure 2). The branchiostegal rays in each specimen number  $4 + 2$ , all about equally robust. The upper-posterior 4 are very closely approximated basally, where inserted on the epihyal; the lower-anterior 2, on the ceratohyal, are well separated from the upper 4 and from one another. The postclavicle is very long and slender. The main otolith (the sagitta) is rather large and asymmetrically oval (Pl. IV, Fig. 2). The two other otoliths are minute.

The vertebrae number 19 in fourteen specimens and 20 in three (including the holotype). The first vertebra is nearly fused to the basioccipital, with sutures barely apparent, except, weakly, at the condyles, and is about three times as broad as long; its lines of ossification converge backward from the condyles. The second vertebra is about as long as it is broad on its anterior suture, which is much more prominent than those that follow in the trunk region and is definitely broader than its posterior suture. The next three vertebrae are definitely the longest, more than twice as long as broad. The next two or three become sharply and progressively reduced in length, and the sutures become stronger, to approach those of the much less rigidly conjoined posterior vertebrae. The next several vertebrae are nearly square. Those more posterior become about two-thirds as broad as long. The length remains nearly uniform. The hypural plate (included as usual in the vertebral count) is much elongated.

**FINS.**—The dorsal and anal fins are narrow lappets. The depressed length of the dorsal is about equal to the length of the snout and approximates two-thirds the length of the anal fin, which reaches approximately to the lower end of the caudal base. The dorsal originates about an eye length behind the anus, and the anal is inserted about halfway between the dorsal origin and the caudal base. Medially the margin of the caudal fin is rounded, and there is a slight tendency toward a rounded production of the upper and lower corners. The pectoral is broad and rounded. The almost cordlike pelvics, which originate about midway between the front of the mouth and the anus, extend outward from the flat ventral surface approximately to the edge of the expanded disk. Outward, the pelvics are broadened and

obliquely truncated, with a pointed outer-posterior tip.

**COLORATION.**—In preservative the colors are drab. The ground color is purplish gray above and whitish below, with some darkening about the chin. The one really conspicuous feature is the pair of stripes. These are not noticeably light-centered. The stripe of each side begins about the length of the cornea behind the orbit, and is rather broad, rounded, and somewhat intensified anteriorly. It continues backward along the lateral line, usually with some weakening and narrowing obliquely above the gill pore. There is some intensification along the lateral line back to about the front of the dorsal fin. In some specimens the band extends backward more or less behind the dorsal fin, either continuously or interruptedly. Behind the head there is a very slight darkening along the middorsal ridge anteriorly, with some broadening and intensification about the dorsal. Usually, especially in smaller specimens, the ground color becomes distinctly lighter just within the dark band on each side. The snout is considerably darkened, especially in larger specimens, and the front of the face back to below the lowest point of the orbit is definitely darkened. Usually there is also a dark blotch behind the posteriormost part of the eye. In the smaller specimens, another dark band, which is separated by a light bar from the other dark markings just described, extends from the eye to near the corner of the mouth. The smallest specimen also shows some radial markings on the eye.

The pectoral and caudal fins are considerably darkened outward, particularly on the sooty membranes. The dorsal fin is dusky, but the anal is pale, with some dark toward its tip. The pectorals are dark both below and above, but the pelvics are whitish. In the youngest specimen, the outer two-thirds of the dorsal and caudal are nearly jet black, as is the outer half of the anal, except on the front edge.

**LIFE COLORS.**—When received, several of the specimens varied from pink to deep red on the lower surface, and some showed red in the two dark dorsal stripes. The fresh colors were most vividly retained in specimen H 53-196, which on receipt was described as follows: upper parts, purplish gray; rather blue-gray on tubercles, and in an irregular blotch near middle of each side of disk; the two dark streaks, reddish brown; underparts, bright rose-red, becoming white or

whitish on the lower (but not the upper) surface of the pelvics, on the outer tip of the anal, and, weakly, on the lower border of the caudal, also on the esca (but not the red stem) of the illicium; pectoral rays, pink-gray, encroached by the widening, blackish interradiial streaks; the fin becoming almost solidly blackish inside the narrow red outer border.

FOOD.—Several of the X-ray photographs display food items, comprising, among the definitely recognizable animals, small mollusks, mostly snails, and small crabs.

#### ACKNOWLEDGMENTS

As usual, I stand in debt to many. For the gift or loan of specimens of the new species, and for data regarding them, I am grateful to the fishermen mentioned in the list of specimens; and to Anita B. Daugherty, California Department of Fish and Game; Margaret H. Storey and Margaret G. Bradbury, Stanford University; Albert W. C. T. Herre, University of Washington; J. H. Applegate, California State Polytechnic College; W. E. Lundy, Panama Canal Natural History Society; and the Allan Hancock Foundation of the University of Southern California. Anita B. Daugherty, Margaret G. Bradbury, Albert W. C. T. Herre, and John Treadwell Nichols (of the American Museum of Natural History) have all relinquished to me the privilege of first describing the new species. William C. Schroeder of the Museum of Comparative Zoology made the types of *O. porrectus* available, arranged for photographs, and took some supplementary measurements. Leonard P. Schultz opened the collections of the United States National Museum. Nobuo Egami kindly took X-ray photographs of all available specimens. Margaret M. Irwin, when connected with the Santa Barbara Museum of Natural His-

tory, made available data on specimens of *Zalieutes elater* and provided a photograph (Pl. IV, Fig. 3).

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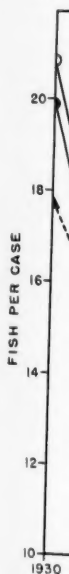
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## Relation of Adult Pink Salmon Size to Time of Migration and Freshwater Survival

BERNARD EINAR SKUD

THE two-year life span of the pink salmon, *Oncorhynchus gorbuscha* (Walbaum), is climaxed by spawning activities in the fall. The eggs, laid in gravel beds of

streams, incubate for 5 to 7 months. In the spring the young work out of the gravel and migrate seaward. Environmental conditions during the period of incubation are



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known to affect the freshwater survival but the degree of their influence has not been measured. Studies at Sashin Creek, Little Port Walter, Alaska, indicate that biological as well as environmental factors determine the rate of survival. The purposes of this paper are to show the relationship between adult size and time of spawning and to discuss the possible influence of this relationship on the survival of young in freshwater.

In Southeastern Alaska the spawning migrations begin in late June and continue into October. The races comprising the migrations can be separated readily into

the catch or in spawning runs entering streams and by estimating from the number of fish utilized per case of canned salmon. Though more precise, fish length data from the catch and spawning runs are not always available and do not furnish consecutive years of information needed for this analysis. On the other hand, cannery records do provide comparisons of average fish size for many years. The number of fish per case has ranged from 12 to 24 throughout the years.

This average number of fish per case reveals yearly fluctuations in adult size that

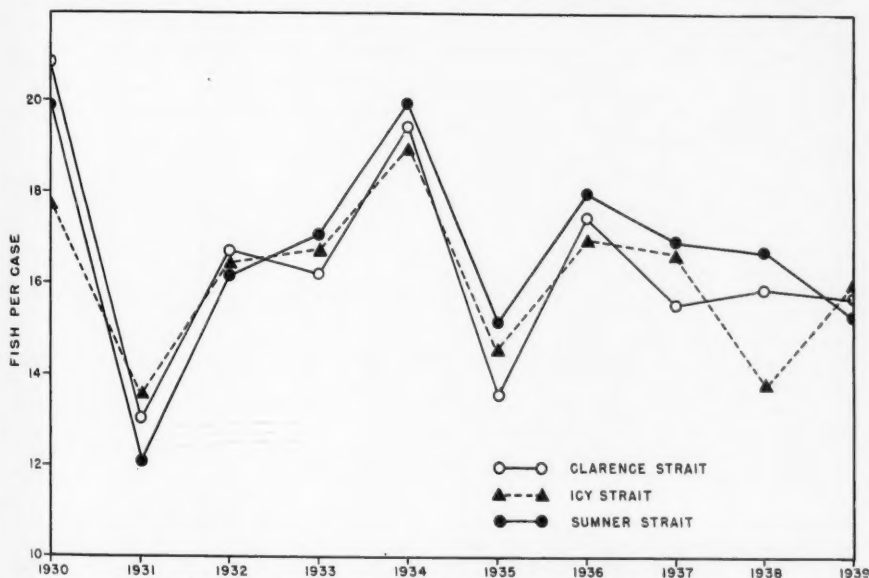


Fig. 1. Fish per case in three fishing districts, Southeastern Alaska, 1930 to 1939.

two seasonal groups commonly called "early" and "late" runs. The "early" runs characteristically reach their spawning streams in July and August and the "late" runs in September and October. In this paper "early" and "late" runs will be designated July and September runs.

#### SIZE OF PINK SALMON AT MATURITY

At the outset of their seaward migration, the young salmon weigh less than 0.4 grams and rarely attain a length of 40 mm. Over 90% of the growth is made during their oceanic life; the returning adults weigh from 2 to 11 pounds and measure up to 700 mm. (standard length).

The size of adult pink salmon can be determined by measuring individuals in

are remarkably similar in three distinct fisheries with wide geographic separation in Southeastern Alaska (Fig. 1). Hoar (1951) reported a similar regularity in size fluctuations in the pink salmon fisheries of British Columbia. The simultaneous changes in size are of great significance, for they appear to arise from a common causal factor or factors that influence the pink salmon population as a unit.

One biological explanation of the size variations from year to year is based on population density and the resulting competition among the individual salmon for food in the ocean as their numbers increase or decrease (Davidson and Vaughan, 1941).

Recent data (Skud, unpublished) from the

salmon fisheries of Southeastern Alaska indicate that pink salmon growth is independent of population density; similarly, Neave (1953) states that there is no evidence of an inverse association between growth and abundance in the British Columbia fishery. The mechanisms involved in the size fluctuations from year to year remain obscure, but the relative importance of population density cannot be ignored and perhaps should be considered on both an inter- and intra-specific basis.

#### RELATION OF FISH SIZE TO THE TIMING OF THE RUN

Davidson and Vaughan (1941) show that a significant correlation exists between size of pink salmon and times of the spawning

1942, and fork length was used after that date. A conversion factor, 0.773, was determined to convert fork length to body length. The size of adult fish and time of arrival at Sashin Creek are compared in Figure 3. Owing to secondary sexual characteristics, female measurements are used because they are less variable than those of the male. Two points on the figure are questionable. The arrival date for 1937 is doubtful due to a severe flood that washed out the weir during the second week of September. That is, the date that 50 percent of the run was completed would be later than August 25, as shown on the graph. Field notes did suggest, however, that the majority of the run was completed prior to

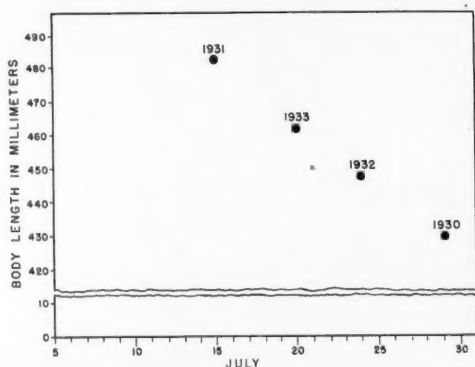


Fig. 2. Comparison of average length of adult females and date that 50 percent of the run passed through the counting weir at Snake Creek, 1930-1933.

migrations. The data were gathered from the pink salmon catch of the Clarence Strait fishery and the times of migrations were determined from catches of traps operated in this area. In the years salmon entered the fishery early in the season, the population was composed of large fish and in the years of later migration, the salmon were smaller.

There is evidence that this same relationship holds when fish ascend their home streams to spawn. Data gathered at Snake Creek, Etolin Island, (Fig. 2) are from Davidson and Vaughan (1941). The runs were earlier in years in which the average length of fish was greater.

Additional data on the size of the spawning adults were collected for most years of operation at Sashin Creek, Little Port Walter. The measurements were not standardized; body length (excluding head and tail) was measured from 1934-38 and during

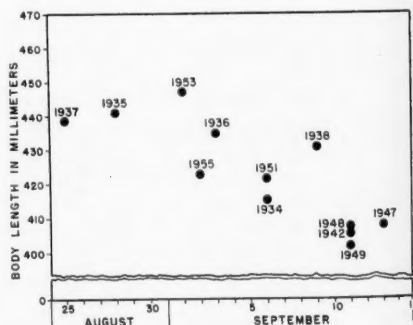


Fig. 3. Mean length of female pink salmon and date that 50 percent of the run passed through the counting weir at Sashin Creek.

the flood and the resultant error is not considered significant. The high average length of fish in 1953 is based on measure-

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ments of only 23 females, which is not considered to be an adequate sample. Nonetheless, two facts suggest that the distortion may not be too great. First, the sampling method used in 1953 provided for an unbiased selection of the fish to be measured. The sample included every tenth female that passed through the weir during a given period. Secondly, the statistics from various fishing districts show that the number of fish per case of canned salmon was significantly lower in 1953 than the average and indicates that the fish were exceptionally large<sup>1</sup>. This evidence suggests that the relative position of the 1953 point in Figure 3 can be accepted. These data show that early runs are associated with larger fish (correlation coefficient = -0.84,  $p < 0.01$ ).

Because time of arrival at the weir does not necessarily indicate time of spawning and since no consecutive data are available on spawning time, the date that 50 percent of the run passed through the weir was selected as the time which was most representative of the peak of spawning. This does not imply that the 50 percent date of passage through the weir is coincident with the peak of spawning, but rather assumes that the peak of spawning will fluctuate from year to year in a manner not unlike that of the 50 percent arrival time. The conditions at Sashin Creek, Little Port Walter, are such that upstream movement of salmon is rarely, if ever, impeded by physical factors. At this station, Davidson et al (1943) tested, by means of correlation and path coefficient analyses, the interrelationship between various environmental conditions and their influence upon the upstream movement of salmon. Results of this work showed that rainfall or stream level may affect the movement upstream, but unless the salmon were sexually mature and ready to enter the stream they did not react to changes in its water level. These findings and unpublished field notes from Sashin Creek support the assumption that arrival time and spawning time fluctuate in a similar manner.

With the size-time relationship established between years, the same phenomenon within a year or run can be examined. In 1936 F. A. Davidson and S. J. Hutchinson (unpublished) sampled catches in two com-

mercial traps in Southeastern Alaska. Trapped fish show no marked change in body structure owing to sexual development and both male and female measurements were included in this comparison. Davidson and Vaughan (1941) showed that the mean length of males was approximately 40 mm. greater than that of females. The number of males and females in the trap samples was not available. As shown later, the means of these samples were not significantly different. This fact indicated that the variation of sex proportions in successive samples was not extreme and possible distortion from this source was considered minimal. Samples of 25 fish each were measured every few days for a month. In combined samples of 100 fish, the mean body length at the Cape Chacon trap between July 18 and 26 was 434.40 mm.; between July 28 and August 7, 431.03 mm.; and between August 13 and 23, 429.84 mm. The standard error of these means was 3.01, 2.36 and 1.68 respectively. The means were not significantly different. The original measurements from the Dall Head trap were not available but the mean length for combined samples of 100 fish for the same 10-day periods were 439.69 mm. in the first, 436.14 mm. in the second, and 430.03 mm. in the third. Assuming that the probability of each possible combination of large, medium and small sample means is equal and that the two experiments are independent, the probability of obtaining the observed distribution in both the Cape Chacon and Dall Head samples in 2.8 percent.

The data available for examination of the size-time relationship within a run at Sashin Creek is limited. Length samples of adults were taken sporadically during given runs. As in the between years comparison at this stream, male measurements were not used because they are more variable than those of the female. Samples were limited to less than 50 fish each and were usually taken at 2-week intervals. The mean difference between early and late samples was 6 mm. In some cases, the differences were not greater than those expected by random sampling errors. However, in 8 out of 9 years the mean length of earlier fish was greater than that of fish arriving later in the run. Assuming that both large and small fish had an equal chance of appearing early in the run, the probability of obtaining the observed distribution is 1.7 percent.

The low probable occurrence of the ob-

<sup>1</sup> The number of fish per case in the years used in Figure 3.

Year	Juneau District	Ketchikan District
1953	16	14
1951	18	15
1949	23	20
1948	23	19
1947	23	19

served sequence of means in both the trap and stream data indicated that the distribution of fish size with time was influenced by a causal agent or agents other than chance. The biological significance of such small differences in length may be questioned, but this evidence from within a run does lend support to the size-time phenomenon as it occurs between years.<sup>2</sup> Hoar (1951) also reported that larger (by weight) fish entered the British Columbia fishery earlier within a season. He suggested that there was a relationship between rate of growth, onset of sexual maturity, and availability to the fishery.

Annual mean lengths of the Sashin Creek data were undoubtedly affected by the seasonal change of length within a run. The possible distortion was considered minimal for two reasons. First, annual means were determined from samples taken at varying intervals during the run. And secondly, the mean difference of annual length measurements were much greater than mean differences of samples taken during the run.

Thus these data indicate that: 1) adult migrations which occur earlier in one year than another are usually composed of larger fish, and 2) the females arriving early in a run are usually larger than late arrivals within the same run.

#### RELATION OF TIMING TO SURVIVAL OF THE PROGENY IN FRESHWATER

Freshwater survival of pink salmon at Sashin Creek is measured by the operation of a two-way weir, adults being counted as they ascend to spawn and the young as they migrate to sea (Table I). Female pink salmon average approximately 2,000 eggs per individual and survival has been calculated by dividing the actual downstream fry count by the potential egg number using the above average.<sup>3</sup>

The correlation coefficient between the time that 50 percent of the adult migration was completed and the rates of survival provides a highly significant value of  $-0.87$ ,  $P < 0.01$ . The comparison does not include the 1950, 1952 and 1954 data because of

the small numbers of spawners. The correlation indicates that early time of arrival at the weir is associated with higher freshwater survival. A direct comparison may be made by a simple average survival from: 1. The four earliest dates of arrival; 2. The five "middle" dates; and 3. The four latest dates of arrival. These are respectively 8.8, 2.1 and 1.0 percent. It may be concluded that the factors associated with early arrival result in better survival. Of these factors the early period of incubation may well be the most important. This time-survival relationship found at Sashin Creek may be applicable to other September runs. However, the differences of environmental conditions could conceivably reverse or preclude a similar relationship in July runs.

If, as the correlation suggests, years of early migration provide better survival than years of late migration, similarly, early arrivals in a run may provide better survival than late arrivals of the same run and the first portion of a run may be of greater importance to the escapement than the later portion.

The question may be raised, that if early migrations provide better survival, why then have not the runs increased in number and become progressively earlier? One hindrance to the runs becoming progressively earlier is the size fluctuation, for if oceanic conditions do not promote growth to large size, adults will not return as early as their progenitors. Secondly, the changes in environmental conditions experienced by the eggs and fry during freshwater existence can readily prevent increasing runs if adverse conditions exist for one or more years.

#### THE EFFECT OF CLIMATOLOGICAL FACTORS DURING THE INCUBATION PERIOD

The relationship of climatological factors to the freshwater survival of pink salmon warrants attention. Rainfall is measured at Little Port Walter is accordance with methods of the U.S. Weather Bureau. Temperatures have been measured by seven-day thermographs, including temperature of the air, surface water and water 6-inches within the gravel of the spawning bed (depth of average pink salmon nest). For a detailed discussion of the effects of climatological factors on survival, the reader is referred to papers by Pritchard (1948) and Neave (1953).

In some years freshwater survival rates at Little Port Walter were either at a lower

<sup>2</sup> Attention is called to the fact that the relation of size to time is also in evidence during the seaward migration of the fry. Skud (1955) has shown that, at a given length, the weight of March migrants is greater than April migrants and April migrants greater than fry migrating in May.

<sup>3</sup> This involves a small error because the fecundity changes with the size of the female. The maximum error on an average, however, is only 10 percent and is not of a magnitude which would account for the large observed differences in survival rates.

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or higher rate than might have been expected from the relation of percentage survival to time of the run; it is possible that these anomalies were caused by climatic conditions. For example, in 1943 when 50 percent of the migration had been completed by September 10, percentage survival was 1.5, a figure which is bettered in three years which have similar dates of arrival. During the incubation and post-hatching

of the mildest on record, temperatures seldom dropping below freezing. These optimal temperatures, undoubtedly, resulted in fewer casualties than would normally be expected during the winter.

#### DISCUSSION

The purpose of this paper has been to show that there is a relationship between the adult size of pink salmon and the time of

TABLE I  
ANNUAL COUNTS, ARRIVAL DATES AND PERCENTAGE SURVIVALS OF PINK SALMON IN SASHIN CREEK, LITTLE PORT WALTER, ALASKA

Year	Date 50% spawners in the stream	Number of adult females	Potential number of eggs	Number of fry migrating seaward following spring	Percent freshwater survival
1934	Sept. 6	3,401	6,802,000	—	—
1935	Aug. 28	3,036	6,072,000	—	—
1936	Sept. 3	2,582	5,164,000	—	—
1937	Aug. 25	3,543	7,086,000	—	—
1938	Sept. 9	3,234	6,468,000	—	—
1939	Sept. 4	8,415	16,830,000	—	—
1940	Sept. 3	26,429	52,858,000	3,402,830	6.4
1941	Sept. 15	44,339	88,678,000	1,024,364	1.2
1942	Sept. 11	40,751	81,502,000	674,672	0.8
1943	Sept. 10	7,490	14,980,000	227,673	1.5
1944	Sept. 9	1,952	3,904,000	104,113	2.7
1945	Sept. 12	2,531	5,062,000	41,900	0.8
1946	Sept. 14	368	736,000	966	0.1
1947	Sept. 13	667	1,334,000	26,454	2.0
1948	Sept. 11	256	512,000	9,016	1.8
1949	Sept. 11	2,400	4,800,000	176,025	3.7
1950*	—	43	—	—	—
1951	Sept. 6	2,031	4,062,000	379,585	9.3
1952*	—	20	—	—	—
1953	Sept. 1	665	1,330,000	94,531	7.1
1954*	—	—	—	—	—
1955	Sept. 2	5,169	10,338,000	1,266,178	12.2

\* Data from these years not used in comparisons made in the text, since the number of spawners was not considered sufficient for the analysis.

period of the 1943 brood several floods occurred which had catastrophic results on eggs and fry still in the gravel of the spawning beds. Thousands of eyed eggs and fry were found stranded on the stream bank following the scouring effects of the floods. This damage exceeded any observed subsequently or previously and could well account for the low rate of survival. As a second example, the incubation period of 1947-48 resulted in a fairly high survival rate, yet the time of arrival was late and supposedly would tend to provide a poor survival. This incubation period was one

migration to their home stream, Sashin Creek. The possible importance of arrival time to survival in freshwater is discussed. The element of timing and its relation to salmon runs is not new. Davidson and Vaughan (1941) stress the time factor in the commercial fishery and Pritchard (1937) and Davidson et al (1943) consider the timing of runs to their home streams.

The high coefficient of correlation between arrival time and survival does not preclude the effect of other factors. The importance of other elements and their influence upon survival merit attention. Per-

haps the most significant factor not taken into account in the present work is predation. The investigations of Ricker (1953) and Neave (1953) point to the importance of predators on survival.

#### CONCLUSIONS

The conclusions of this report are:

1. Yearly fluctuations in the average size of pink salmon appear to be uniform throughout the Southeastern Alaska fishery which suggests that these fish are affected as a unit by environmental factors met during their ocean existence.
2. During years in which the fish are large the runs tend to appear earlier than in years in which the runs consist of smaller fish.
3. Within a season, fish arriving earlier are larger than individuals arriving later in the same run.
4. At Sashin Creek statistical evidence suggests that years of early runs may provide for better survival of young during the freshwater incubation than years of late runs.

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## Additional Pleistocene Fishes from Kansas and Oklahoma

C. LAVETT SMITH

IN a previous paper (Smith, 1954) I reported on some Pleistocene fish remains of the Berends Local Fauna from Beaver County, Oklahoma. Additional collecting in that part of the High Plains has yielded fish fossils from strata of comparable age in two other localities. Further work at the Berends site has not added more species to the faunal list but additional fossil skeletal parts of *Lepisosteus* sp., *Catostomus commersoni* (Lacépède), *Ictalurus melas* (Rafinesque), and *Perca flavescens* (Mitchill) have been collected. The Berends molluscan fauna has been reported by Taylor (1954), and the mammalian fauna by Starrett (1956). The faunas from the other two localities, Doby Springs and Butler Spring, have several species in common with each other and with the Berends fauna and seem to be of the same Illinoian Glacial age as the Berends fauna.

#### ACKNOWLEDGMENTS

Dr. Claude W. Hibbard of the University of Michigan Museum of Paleontology (UMMP) made available the specimens forming the basis of this report and contributed much aid and advice during the preparation of the manuscript. Dr. Hibbard also led the field parties in the collecting of these specimens and, in the company of Dr. Arthur J. Meyers of the Oklahoma Geological Survey, first visited the Doby Springs locality in July 1955. Mrs. L. Dees, owner of the property on which the Doby Springs quarries are located, graciously gave permission to collect the fossils there. Her daughter, Miss Portia Dees, kindly furnished certain locality data. The field parties are also grateful to Horace G. Adams II and Horace G. Adams III for allowing them to work the Butler Spring locality on their ranch.

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The following members of the University of Michigan Museum of Paleontology field party contributed much hard work: John J. Stephens, Robert L. Carroll, David S. F. Winsted, Louis Thaler, Gerald R. Paulson, Michael O. Woodburne, and William G. Melton. The drawings were made by Mrs. Bonnie Hall. All of these people have my sincerest gratitude.

#### THE DOBY SPRINGS LOCAL FAUNA

Located in T27N, R24W, N $\frac{1}{2}$ , SW $\frac{1}{4}$ , Sec. 10, Harper County, Oklahoma, the Doby Springs fossiliferous strata are lake deposits. As in the Berends fauna, there are mollusk, amphibian, bird, and mammal fossils associated with the fishes. Detailed studies of the history, stratigraphy, age, and fossil mammals of the Doby Springs beds are being made by John J. Stephens in cooperation with Drs. Carl C. Branson, David B. Kitts, and Arthur J. Meyers of the Oklahoma Geological Survey and the University of Oklahoma. Approximately fourteen tons of matrix washed according to the method of Hibbard (1949) yielded the following species.

#### Family Catostomidae

*Catostomus commersoni* (Lacépède). White sucker—Referred material: UMMP 34840 including 2 supraoccipitals, 2 left dentaries, 1 left hyomandibular, 1 right hyomandibular, 1 fragmentary right opercle, 1 incomplete mesethmoid, 8 fragments of left pharyngeal arches, 5 fragments of right pharyngeal arches, 1 complete right pharyngeal arch, and 21 isolated pharyngeal teeth. These elements agree very closely with recent material. In particular, the configurations of the mesethmoid, supraoccipital, pharyngeal arches and pharyngeal teeth seem to be diagnostic.

This species is now found from the upper Mackenzie River basin to the Labrador Peninsula and southward to the Saluda River in South Carolina. In the Mississippi River drainage it occurs south to the Tennessee River System and in the uplands of northern Arkansas and northeastern Oklahoma. It is absent south of north-central Kansas but does occur in the headwaters of the Arkansas, Canadian and Pecos rivers. Its distribution is probably limited by suitable gravel areas for spawning.

#### Family Cyprinidae

Minnow pharyngeal arches and pharyngeal teeth are abundant in the collection but identification of these isolated parts is, at

best, unsatisfactory and the determinations given here must be considered tentative.

*Pimephales promelas* Rafinesque, Fathead minnow (Figure 1 A-B).—Referred material: UMMP 34847, fragments of 6 left and 6 right pharyngeal arches, and 1 complete left pharyngeal arch, UMMP 34846 (Fig. 1). The broad, sharply curved pharyngeal bone which has the anterior limb short and nearly parallel to the posterior edentulous process seems

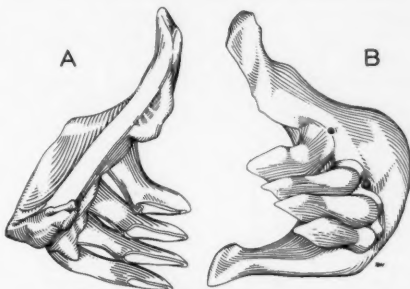


FIGURE 1. Pharyngeal arch of *Pimephales promelas*. A. Dorsal view of left pharyngeal (UMMP 34846). B. Medial view of same.



FIGURE 2. Medial view of right pharyngeal arch of fossil *Hybopsis* cf. *gracilis* (UMMP 34848).

to be diagnostic for this species. The teeth have long, well developed grinding surfaces without crenulations. There is a small but distinct hook distally on some teeth of some of the arches. In others it is lacking, presumably having been worn off during life. Tooth formula 4-4.

This species is found today throughout central North America from northern México to central Canada. It still occurs in the High Plains area.

cf. *Hybopsis gracilis* (Richardson), Flat-head chub (Figure 2).—Referred material:

UMMP 34839, fragments of 4 left and 10 right pharyngeal arches, and UMMP 34848, 1 incomplete right pharyngeal arch (Fig. 2). The tooth formula seems to be 2,4-4,2 although all of the left arches are broken and there is a possibility that there were 5 teeth in the main row (2,5-4,2). The shape of the arch resembles that of both *Hybopsis gracilis* (dental formula 2,4-4,2) and *Gila elongata* (which has 2,5-4,2 teeth). Therefore, the identification is tentative pending the collection of a complete left pharyngeal arch.

*Hybopsis gracilis* is a plains minnow ranging from New Mexico north to the Peace River in British Columbia. Its presence in the area during glacial times is, therefore, not surprising.

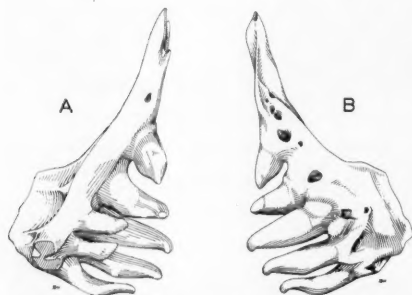


FIGURE 3. Pharyngeal arch of *Semotilus atromaculatus*. A. Dorsal view of left pharyngeal arch (UMMP 34844). B. Ventral view of same.

*Semotilus atromaculatus* (Mitchill), Creek chub (Figure 3 A-B).—Referred materials: UMMP 34844, 1 incomplete left pharyngeal arch and UMMP 34845, 10 left and 16 right pharyngeal arches, all fragmentary.

Recent material indicates that this species is rather variable in number and shape of the teeth but the fossil series seems to fall within the limits of this variation. The tooth count (2,5-4,2), the shape of the arch, and the development of grooves on the posterior surfaces of the middle and next posterior teeth in the main row in larger specimens seem to be diagnostic.

The Recent distribution includes small and moderate-sized streams from Montana and the Red River of the North, east to the Gaspé Peninsula and south on both sides of the Appalachians to northern Florida and eastern Texas. Although not found in the area today, the limiting factor is perhaps lack of suitable spawning conditions (gravel beds) rather than temperature since the species

occurs farther south in the headwaters of the Arkansas and Pecos rivers in Colorado and New Mexico.

*Incertae sedis*.—Additional cyprinid skeletal elements include: UMMP 34851, 1 tripus; UMMP 34852, 3 dentaries; UMMP 34850 and 34853, 54 fragmentary pharyngeal arches. At least 6 additional species seem to be represented but the material is so fragmentary that it cannot be identified with confidence and, although one of these species seems to be new to science, it seems unwise to base a description on such sketchy material.

#### Family Ictaluridae

*Ictalurus melas* (Rafinesque), Black bullhead.—Referred material: UMMP 34843, including 3 Weberian centra, 2 ceratohyals, 4 parasphenoids, 1 right opercle, 2 left opercles, 4 posttemporals, 6 supraoccipitals, 3 premaxillary tooth pads, 4 left and 3 right articulars, 4 left and 11 right dentaries, 1 basioccipital, 3 epihyals, 4 quadrate fragments, 5 cleithra fragments, 2 urohyals, 3 frontal fragments, and 25 miscellaneous fragments. This species is distinguished by the high ridges and long crest of the supraoccipital.

The Recent distribution of the black bullhead is from the Lake Ontario drainage west to Wyoming and south to the Gulf coast. It is the most common bullhead of the plains region.

#### Family Percidae

*Perca flavescens* (Mitchill), Yellow perch.—Referred material: UMMP 34841, consisting of 1 right premaxillary, 1 right opercle, 1 fragmentary right preopercle, 1 nearly complete preopercle, 4 opercle fragments, 1 fragmentary supracleithrum, 1 ceratohyal, 1 incomplete epihyal, 2 dentaries, 2 pharyngeal bones, 2 left and 3 right articulars, 28 opercular fragments. The yellow perch is one of the most abundant forms in the Berends fauna and was also found at Butler Spring. The form of the preopercle and some other bones is distinctive.

The present distribution of the yellow perch is from Lesser Slave Lake of the Mackenzie Basin east to the Hudson Bay drainage and south to the northern parts of Missouri, Illinois, Indiana, Ohio and western Pennsylvania. On the Atlantic slope of the Appalachians, it ranges from New Brunswick to South Carolina.

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## Family Centrarchidae

*Lepomis* cf. *cyanellus* Rafinesque, Green sunfish.—Referred material: UMMP 34842, 1 fragment of left preopercle, 2 fragments of left pharyngeal bones. There is very close agreement with recent skeletal material. The serrulations on the lower limb of the preopercle seem especially diagnostic.

The green sunfish is characteristic of slow-moving streams and lakes from Wyoming and South Dakota to southern Ontario and western New York and south to Alabama, north-eastern México and New Mexico.

## THE BUTLER SPRING LOCAL FAUNA

The Butler Spring Local Fauna was taken from deposits ("High Terrace," Hibbard, 1943: 190) located on the XI Ranch in the T34S, R29W, SE¼, Sec. 32, Meade County, Kansas. Five species of fishes were collected by Hibbard and parties during the summers of 1956 and 1957. An extinct turtle, *Emys* *twentiei*, related to the Recent *Emys blandingi* was described by Taylor (1943) from this deposit, and Tihen (1955) recorded a giant neotenic salamander, *Ambystoma tigrinum*, from the same horizon and locality.

## Family Lepisosteidae

*Lepisosteus* sp., Gar.—Referred material: UMMP 34855, 1 fragment of upper jaw and 16 assorted scales belong to a species of *Lepisosteus* that I cannot with certainty determine.

Gars are found in larger streams and lakes from the upper Missouri valley of Montana and North Dakota through the drainage of the Red River of the North in North Dakota and Minnesota and the Great Lakes drainage exclusive of Lake Superior, to the St. Lawrence River. They range southward to Lake Nicaragua in Central America.

## Family Catostomidae

*Catostomus commersoni* (Lacépède), White sucker.—Referred material: UMMP 34856, 2 fragmentary pharyngeal arches and 1 incomplete vomer are of this species. The distal expansion of the pharyngeal teeth distinguishes this species from its near relative, *Catostomus catostomus* (Forster).

## Family Ictaluridae

*Ictalurus* cf. *punctatus* (Rafinesque), Channel catfish.—Referred material: UMMP

34858, 2 fragments of right cleithra, 1 fragment of pectoral spine, 1 basal half of right pectoral spine, 1 fragmentary posttemporal, 1 base of dorsal spine. The largest cleithrum fragments are from fish that had a standard length of at least 585 mm. The determination is based upon the size as well as the structure of the pectoral spine and the configuration of the humeral process of the cleithrum.

The channel catfish occurs in lakes and rivers from the northern end of Lake Huron and the St. Lawrence drainage of Quebec to

TABLE I  
A COMPARISON OF THE FISH FAUNAS OF THE FOSSIL LOCALITIES DISCUSSED IN THE TEXT

Species	Berends	Doby Springs	Butler Spring
<i>Lepisosteus</i> sp.	×		×
<i>Esox masquinongy</i> Mitchell	×		
<i>Catostomus commersoni</i> (Lacépède)	×	×	×
<i>Notemigonus crysoleucas</i> (Mitchill)	×		
<i>Semotilus</i> cf. <i>atromaculatus</i> (Mitchill)	×	×	
<i>Semotilus</i> sp.	×		
<i>Hybopsis gracilis</i> (Richardson)		×	
<i>Pimephales promelas</i> Rafinesque		×	
<i>Ictalurus melas</i> (Rafinesque)	×	×	×
<i>Ictalurus punctatus</i> (Rafinesque)	×		×
<i>Lepomis cyanellus</i> Rafinesque	×	×	
<i>Perca flavescens</i> (Mitchill)	×	×	×
<i>Aplodinotus grunniens</i> Rafinesque	×		

Cumberland Lake in Saskatchewan and south to the Rio Panuco Basin in northeastern México.

*Ictalurus melas* (Rafinesque), Black bullhead.—Referred material: UMMP 34857, 1 left articular, 4 left and 1 right pectoral spines, 1 fragment of posttemporal, 1 ? fragment of left cleithrum. All agree closely with the fossil material from the Doby and Berends deposits as well as with Recent specimens of this species.

*Perca flavescens* (Mitchill), Yellow Perch.—Referred material: UMMP 34860, 1 fragment

of right preopercle and 1 right supracleithrum.

#### DISCUSSION

All three of the faunas contained remains of the yellow perch (*Perca flavescens*), the white sucker (*Catostomus commersoni*), and the black bullhead (*Ictalurus melas*). The smallest collection, from the Butler Spring locality, contained two other species, a gar (*Lepisosteus* sp.) and probably the channel catfish (*Ictalurus punctatus*), which were also found at the Berends locality (Table I). Presumably, more collecting at the Doby Springs and at the Butler Spring localities would yield more species common to all three localities. The Doby Springs deposits contain several species of minnows not found at the Berends site and this possibly indicates that the locality was more of an upstream, pond situation with smaller streams flowing into it. The absence of the drum, gar, and channel catfish would seem to bear this out.

## A Description of a New Species of Stomiid from the North Pacific Ocean<sup>1</sup>

WILLIAM ARON AND PETER MCCRERY

THE fishes described here were captured during a midwater trawling survey conducted in the North Pacific by the University of Washington, Department of Oceanography (Aron, 1958). The work was done aboard the M. V. BROWN BEAR on a cruise devoted primarily to research for the International Geophysical Year program and was supported in part by Contract NR 083-012 with the Office of Naval Research. The authors are grateful to Dr. Robert Paquette and Mr. Robert Gregory, Party Chief and Assistant Party Chief for the cruise, for their full cooperation during the trawling program. The authors are particularly grateful to Mrs. Edith Haselwood of the Department of Oceanography for her assistance in the literature research; to Dr. Arthur Welander of the College of Fisheries, University of Washington, for his advice and help during the study; and to Drs. Leonard P. Schultz and Ernest A. Lachner of the U. S.

<sup>1</sup> Contribution No. 217 from the Department of Oceanography, University of Washington.

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National Museum for their constructive criticisms of the original manuscript.

All specimens were taken south of 50° N latitude during night hauls made with a modified Isaacs-Kidd midwater trawl (Isaacs and Kidd, 1953; Aron, 1958). The region of their capture has oceanographic significance in that the 50° parallel appears to be a boundary between cold, predominantly Sub-Arctic water to the north and warmer, North Pacific Drift water to the south. The species of *Bathophilus* are found typically in warm waters. Although the area north of 50° N latitude was extensively sampled during the cruise no *Bathophilus* were taken, whereas two other stomiatoids, *Tactostoma macropus* and *Chauliodus macouni*, were commonly captured. Another indication of the faunal differences between the areas north and south of the 50° parallel was in the capture in the south of two unidentified leptocephali having standard lengths of 205 and 208 mm., and three specimens of the rare stomiatid, *Aristo-*

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*stomias scintillans*. These, combined with one other specimen caught on a previous cruise of the M. V. BROWN BEAR, bring to a total of five the known specimens of *Aristostomias* taken in the Pacific. The temperature in the areas where *B. flemingi*, *A. scintillans*, and the leptocephali were captured was 60° F at the surface and ranged from 44° F at 120

meters to 50° F at 60 meters. Just north of 50° N at similar longitudes the temperature was 54° F at the surface, 40° F at 120 meters, and 43° F at 60 meters.

*Bathophilus flemingi*, sp. nov.

HOLOTYPE—USNM 171004; collected September 19, 1957 at 47° 58' N, 139° 11' W at

TABLE I  
COUNTS AND MEASUREMENTS FOR FIVE SPECIMENS OF *Bathophilus flemingi*  
(Measurements expressed in thousandths of the standard length)

	Holotype USNM 171004	Paratype USNM 171005	Paratype Univ. Wash. 14377	Paratype Univ. Wash. 14378	Paratype Univ. Wash. 14379
Standard length in millimeters	120	116	100	110	88
Total length	1075	1078	1080	1064	1091
Head length	175	181	170	164	170
Depth behind head	125	129	140	145	136
Depth just anterior to pelvic	125	121	130	136	125
Depth from dorsal surface to center of base of right pelvic	108	—	110	81	—
Depth from dorsal surface to center of base of left pelvic	45	—	58	65	—
Length of barbel	2083	345	1880	1527	261
Eye diameter	20	19	21	19	24
Pupil diameter	11	10	12	12	14
Length subocular light organ	6	8	8	7	9
Length postocular light organ	23	20	12	20	16
Length of longest fin ray					
dorsal	100	112	90	91	57
anal	67	112	90	100	45
caudal	100	95	90	82	91
right pelvic	325	362	280	345	—
left pelvic	358	328	250	309	—
right pectoral	583	508	340	391	386
left pectoral	408	388	410	136	250
Number of rays <sup>1</sup>					
dorsal	15	16	16	15	15
anal	17	17	17	16	16
caudal	16	18	19	18	18
right pelvic	17	16	15	15	—
left pelvic	17	15	16	15	—
right pectoral	5	5	7	5	5
left pectoral	5	5	7	5	5
Photophores					
Lateral series:					
opercle-pelvic	13	—	15	15	—
pelvic-anal	14	—	13	12	—
Ventral series:					
isthmus-pectoral	4	—	5	4	4
pectoral-pelvic	6	—	14	15	—
pelvic-anal	6	—	10	13	—
anal-caudal	7	—	—	5	—

<sup>1</sup> The fin ray counts (with the exception of the caudal) were made on the two specimens at the U. S. National Museum by Dr. Schultz.

a depth of 60 meters; standard length 120 mm.

PARATYPES—USNM 171005; collected September 19, 1957 at 47° 58' N, 139° 11' W at

eries 14378; collected September 20, 1957 at 48° 03' N, 134° 40' W at a depth of 225 meters; standard length 110 mm. Univ. Wash. School of Fisheries 14379; collected Septem-

TABLE II  
COMPARISON OF *Bathophilus flemingi* WITH OTHER SPECIES IN THE GENUS

	<i>B. flemingi</i> sp. nov.	<i>B. longipinnis</i> Pappenheim, 1914	<i>B. filifer</i> <sup>1</sup> Garman, 1899	<i>B. ater</i> A. Brauer, 1902 & 1906	<i>B. indicus</i> A. Brauer, 1902 & 1906	<i>B. longipes</i> Regan and Trewavas, 1930
Depth in thousandths of standard length	125-140	125-153	83-111	125	133	100-154
Head in thousandths of standard length	164-181	200-250	125-200	182	222	167-222
Number of rays						
dorsal	15-16	14-16	12-16	17	13	13-16
anal	16-17	15-16	14-17	17	16	13-16
pectoral	5-7	5-8	1	5	4	10-16
pelvic	15-17	11-14	4-5	9	16	7-10
caudal	16-19	—	—	—	—	—
Pelvic light spot	present	not described	not described	not described	not described	present
Subocular light spot in relation to postocular light spot	very close, al- most border- ing	well in front	below	separation dis- tinct, addi- tional light spot under postocular organ	—	separation dis- tinct
Photophores						
Lateral series:						
opercle-ventral	13-15	13-16	—	16	—	14-16
ventral-anal	12-14	10-12	—	13-15	—	9-10
Ventral series:						
isthmus-pectoral	4-5	—	—	—	—	5
pectoral-ventral	6-15	—	—	18	15	17
ventral-anal	6-13	—	—	13-15?	13-15	11
anal-caudal	5-7	—	—	—	—	5

<sup>1</sup> Based on description of (Parr, 1927) and (Regan and Trewavas, 1930).

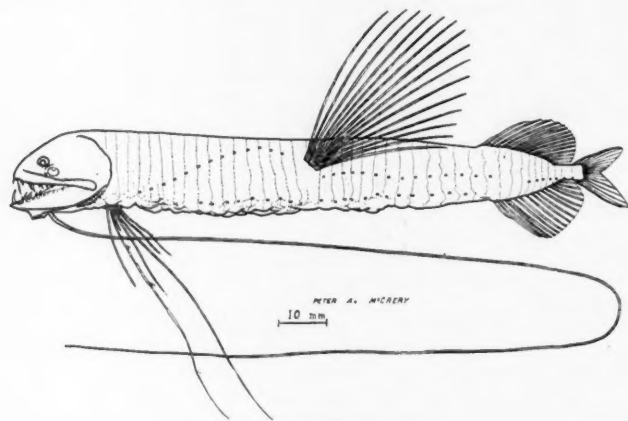


FIG. 1. *Bathophilus flemingi*.

a depth of 60 meters; standard length 116 mm. Univ. Wash. School of Fisheries 14377; collected September 20, 1957 at 48° 03' N, 134° 43' W at a depth of 60 meters; standard length 100 mm. Univ. Wash. School of Fish-

ber 21, 1957 at 48° 15' N, 130° 05' W at a depth of 120 meters; standard length 88 mm.

*Bathophilus flemingi* is illustrated in Figure 1, and the counts and measurements are given in Table I. In Table II counts and

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measurements for the new species are compared with data for those species of *Bathophilus* to which it seems closely related. *B. filifer* is included because it is the only member of the genus previously recorded as captured in the Pacific, having been taken off Central America and the Galápagos. This species is easily distinguished from *B. flemingi* by its pectoral fin, which consists of a single ray.

*B. flemingi* most closely resembles *B. longipinnis*, but is distinguished from this species by the proximity of the subocular light organ (white spot) to the postocular light organ, and by its smaller head and greater number of pelvic rays. The new species also seems to be characterized by the bullous appearance of its ventral surface. The bullae may be the result of handling; however, their consistency from specimen to specimen indicates that they are a true structure. The bullae may provide a means of expansion following feeding by the fish.

The length of the barbel is uncertain. In the hauls with the specimen having the longest barbel were found pieces of barbel which, if belonging to the specimen captured, would make that barbel about four times the standard length of the fish. It is possible, of course, that the barbel pieces found belonged to a specimen which avoided capture.

Table II shows that the new species may be separated from *B. ater* and *B. longipes* by the greater number of rays in its pelvic fin. *B. ater* has a light spot under its postocular light organ which is not found in the new species. The only specimen of *B. indicus* was unfortunately destroyed (Brauer sectioned the specimen for histological study); however,

it had fewer rays in its pectoral fin than *B. flemingi* and also appears to have had fewer photophores than the new species. *B. longipinnis* is best distinguished from the new species in that the subocular light organ is well separated from the postocular light organ. *B. longipinnis* also appears to lack the light spot associated with the ventral fin, and the ventral series of photophores.

The new species is named in honor of Richard H. Fleming of the University of Washington for his contributions to biological oceanography.

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## An Experimental Study of the "Third Eye" of the Tuatara

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A recent study (Stebbins and Eakin, 1958) of the function of the parietal eye has shown this organ to be important in regulating the exposure of lizards to sunlight. The species studied were *Sceloporus occidentalis*, *S. undulatus*, *Uta stansburiana*, and *Uma inornata*. All may be classed as heliotherms for they largely depend directly upon the sun for elevation of their body temperatures to levels required for daily

activity. When the parietal eye was removed<sup>1</sup> (or covered with aluminum foil) the lizards increased their exposure to sunlight. Although it was expected that the increased heliothermism would result in an elevation of body temperatures no increase was detected. The parietectomized lizards did,

<sup>1</sup> A minor operation referred to throughout as parietectomy; control animals received the same surgery but the parietal eye was left intact. Such individuals are referred to as sham-operated.

however, extend the length of time spent at the "optimum" temperature of the normal activity range. Probably due to accentuation of the basking urge, they were less inclined to retreat in the presence of the observer and thus gave the appearance, at least, of a dulling of the fright reaction. They were restive in captivity and individuals marked and released at previous points of capture in the field moved greater distances than the controls. Histological study of the thyroid gland revealed a tendency toward hypertrophy of the thyroid epithelium and depletion of colloid in captive parietectomized lizards. The overall behavioral changes suggested that the parietectomized lizards were spending their life capital more rapidly than the controls and that the parietal eye was important in helping to insure a proper balance between anabolic and catabolic processes. The "eye" thus appears to be an important homeostatic mechanism in these animals.

In view of these findings it seemed desirable to extend the studies to the tuatara (*Sphenodon punctatum*), the only living reptile other than lizards<sup>2</sup>, that has a median "eye." The similarity in structure between the parietal eye of *Sphenodon* and that of lizards, along with the close correspondence in other parts of the pineal apparatus, suggested similarity in function. Yet the tuatara cannot be classed as a heliotherm even though it sometimes basks (Dawbin, 1949); and it is a very different animal in structure and habits. Its generally nocturnal habits (Dawbin, 1949), low thermal preferences (Bogert, 1953) and low metabolic rate (Milligan, 1923), contrast with the diurnal activity and high thermal preferences of the lizards studied.

It was hoped that study of the tuatara, a reptilian type that appears to have changed little since the Jurassic, might help to shed light on the function of the parietal eye in ancient reptiles. The widespread occurrence of pineal foramina among fossil forms suggests that an eye-like organ was prevalent and in many species relatively much larger than it is today (Edinger, 1955).

Through the generosity of the New Zealand government, professor Richard Eakin and I received, on September 23, 1956, two live tuataras for our parietal eye studies, one animal for experimentation, the other to

serve as a control. The tuataras were males, one slightly larger than the other and are referred to throughout this report as *Sphenodon* "L" (the larger one) and *Sphenodon* "S". Their sizes and weights on April 2, 1957, were as follows: *Sphenodon* "L", 10¼ in. in snout-vent length, weight 749 g. and *Sphenodon* "S", 8 and ¾ in., weight 630 g.

Since in the lizard experiments covering the parietal eye with foil had essentially the same effect as parietectomy, it was decided to avoid the risk of surgery, and to cover the "eye" of the experimental tuatara with a shield to block light and heat.

On the assumption that changes in behavior like those that occurred in the lizards might follow masking the "eye", experimental chambers were constructed to test the reactions of the tuataras to gradients in light and heat. A sand substratum was used and the tracks left by the animals were swept out after each observation. In this way a record of movements was obtained.

It was expected that covering the parietal eye of the tuatara might be followed by increases in (1) exposure to light, (2) locomotory activity, and (3) use of the warm end of the temperature gradient. Special attention therefore was given to these points.

#### EXPERIMENTAL APPARATUS

The experimental apparatus (Fig. 1) provided each animal with a dark runway (A) and one with a step-wise light gradient (B). Openings permitted movement from one passage to the other, but the two sets of runways were separated by a partition that prevented the animals from contacting or seeing one another. The lighted runway consisted of four compartments separated by wood partitions except near the floor where a canvas curtain allowed the animals to move from one chamber to the next. The first compartment at the cool end was kept dark, and illumination in the next 3 chambers was, respectively, 12, 100, and 400 Weston Light Meter readings. A thermal gradient was continuously maintained in the dark runway (3–5°C. to 35–45°C.), but only existed in the adjacent runway (3.5 (average) to 60°C.) when the lights were on. During the first part of the experiments, runway B (Fig. 1) was illuminated from about 8:30 AM to 5:00 PM. On weekends and occasionally during week days, the lights were off. On June 7, about 3½ months after

<sup>2</sup> Not all lizards have a parietal eye. It is absent in geckos and teiids, for example.

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the experiment started, the light gradients were maintained continuously to increase the opportunity for the parietal eye-covered

Variation when refrigeration was on was from  $-3$  to  $9^{\circ}\text{C}$ .

Water was continuously available to the

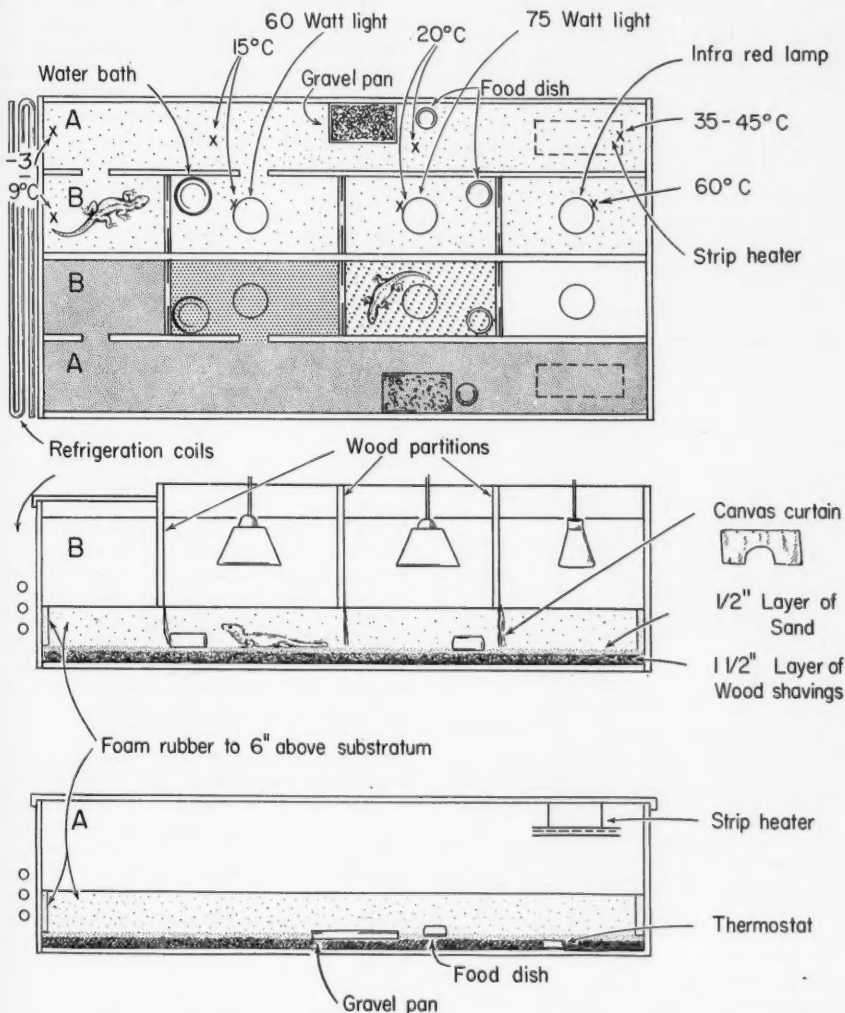


Fig. 1. Experimental apparatus used to study reactions of tuataras to light and heat. Each animal was provided with the same conditions, a continuously dark runway with a thermal gradient (runway A) and a combined light and heat gradient (runway B).

animal to engage in metabolic excesses if it was disposed to do so. Refrigeration of the cold end of the gradient was usually off on weekends to allow for defrosting, at which time the cold end averaged  $12^{\circ}\text{C}$ .

animals and after the first two months of the study a pan of wet gravel was provided. Both tuataras occasionally stationed themselves on this wet surface. Food consisted chiefly of mealworms and newborn rats. Large spiders,

scorpions (with sting removed), Jerusalem crickets, geometrid larvae, and other arthropods were used to supplement the diet.

#### EXPERIMENTAL PROCEDURE

On days when observations were made, at intervals of about two hours or longer, a cloacal temperature reading was taken of each animal, its position in the experimental apparatus noted, the route it had followed in the runways recorded, and its tracks swept out. The tuataras moved so little there was seldom confusion as to the distance travelled between observations.

The foregoing information was recorded for each individual from February 7 to

TABLE I  
BODY TEMPERATURES OF *Sphenodon* BEFORE AND AFTER ATTACHMENT OF A FOIL COVERED CORK DISC TO HEAD

	Number of records	Mean	Range
Before attachment of cork-foil disc			
Experimental, "L".....	154	17.59	6.0-27.0
Control, "S".....	130	18.45	3.5-27.9
After attachment of cork-foil disc			
Experimental (Disc over parietal eye).....	88	17.61	5.0-26.0
Control (Disc in front of parietal eye).....	73	20.54	4.5-26.0

April 15, 1957, before application of the parietal eye shield, in order to provide a basis for interpreting the behavior of the animals after experimentation has begun. On April 15 the parietal eye region of *Sphenodon* "L" was covered with a lens-shaped piece of cork, 10 mm. in diameter, covered on both sides with aluminum foil. It was thought that the cork and the reflective properties of the foil would insulate against heat and light when the animal came to rest beneath the strip heater or infra red lamp (Fig. 1). The parietal eye shield was attached with rubber cement. A similar shield was anchored to the head of the control animal, anterior to the parietal eye.

#### EXPERIMENTAL RESULTS

*Reactions to temperature.*—*Sphenodon* "L" showed no change in cloacal tempera-

tures recorded during a period of two months following covering the parietal eye. The frequency curve for body temperatures had essentially the same shape before and after covering the "eye" and the mean and range in body temperature showed no significant changes (Table I). The control animal (*Sphenodon* "S"), in which the cork-foil disc was attached in front of the eye, showed an increase in its mean body temperature in the course of the experiment. This individual averaged slightly higher in body temperature than *Sphenodon* "L". For about a month it suffered from a plugged and inflamed cloacal scent gland and toward the end of the experiment it had a mild condition of mouth rot. Perhaps these inflammatory conditions disposed the animal to use slightly higher temperatures than *Sphenodon* "L".

The cloacal temperature readings (445 records) of both tuataras are combined in figure 3. The mean was 18.3 and the range, 3.5 to 27.9°C. These figures differ somewhat from those of Mr. William Dawbin (reported by Bogert, 1953). Temperatures taken by Mr. Dawbin at night on Stephen Island, April 23-25 (45 individuals) and on November 4 to 6 (26 individuals), ranged from 6.2 to 13.3°C. (mean  $10.9 \pm .19$ ). Two of three animals caught on the afternoon of April 23 had body temperatures of 14.0 and 18.0°C., respectively. In view of my laboratory findings, it seems likely that had more daytime records been obtainable in the field, there would be greater correspondence in our results. The low laboratory records are surprising, since at 3.5°C. I found the tuataras were unable to crawl, although they could right themselves. Lack of awareness of the route of escape from the cold end of the gradient seems unlikely since *Sphenodon* "S" was found at 3.5°C. two months after the beginning of the study. On the day this low temperature occurred the tuatara, in the course of the morning, moved from the warm end of the gradient to the cold end and then began to dig (about 11:00 AM) in the corner of the box near the refrigeration coils. At 11:50 AM its body temperature was 9.4°C. During the remainder of the day it stayed at this location, digging intermittently. Its body temperature had dropped to 7.2°C. by 1:10 PM, 5.7°C. by 3:30, and had reached 3.5°C. at 4:50 PM. At this time I moved it to a warmer part of the box because I feared the animal might suffer from the prolonged exposure to cold. The substratum temperature at one foot from the end of the runway was around 10°C., thus

the animal must have remained against or in close proximity to the cold end to reach this low temperature. At a body temperature of  $3.5^{\circ}\text{C}$ ., the animal moved its hind limbs feebly through a small arc with the legs extended at approximately a right angle to the body axis. The forelimbs moved somewhat more effectively, perhaps due to slight warming from handling. At  $4.5^{\circ}\text{C}$ ., it could move forward laboriously. It appears from this observation and a similar test with *Sphenodon* "L" that  $3$  to  $4^{\circ}\text{C}$ . is the critical minimum temperature.

I have not wanted to risk killing the animals, hence no attempt had been made to determine the critical maximum temperature tolerance.

It must be concluded that in *Sphenodon* "L", under these experimental conditions, there was no change in temperature reactions during a two months' period following covering the parietal eye with the cork-foil shield.

The laboratory findings accord with the field observations reported by Bogert (1953) and among terrestrial vertebrates show *Sphenodon* to be salamander-like in its thermal characteristics. It is capable of locomotion at temperatures only a few degrees above freezing. It apparently lacks a narrow thermal optimum, and it avoids temperatures that are readily tolerated by all other reptiles (Fig. 2).

**Reactions to Light.**—Exposure to light was measured by scoring the animals in relation to their position in the lighted compartments. An individual in compartment one (the most brightly lighted) received 6 points, in compartment two, 4 points and three, 2 points. Individuals at positions between the compartments, from the brightest (one) to the darkest ones, (four and five), received respectively, 5, 3, and 1 point. Table II summarizes the results. It will be noted that *Sphenodon* "S" used the lighted runways more than *Sphenodon* "L", both before and after the application of the cork-foil shield. Both animals greatly increased their use of light in the course of the experiment, perhaps as a result of adjustment to the presence of the observer, but no change in reaction to light was noted in the parietal eye covered individual.

**Movements.**—On a diagram of the runways drawn to scale, at each observation, a sketch was made of the route followed by the tuataras and the tracks were then obliterated. Later the distances indicated on the diagrams were measured and converted to

actual distances. Distances moved per day were calculated in terms of hours over which the observations were made. Figure 4 summarizes the results.

Throughout the experiment *Sphenodon* "S" was slightly more active than "L". However there was no significant change in relative amounts of movement after covering the parietal eye of the latter. As with the lizards studied, activity was greatest during

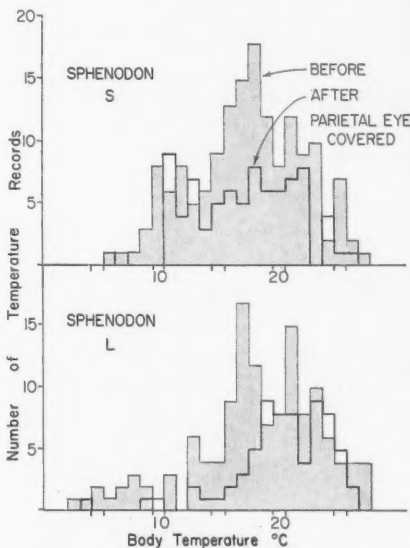


Fig. 2. Body temperatures of *Sphenodon* "L" before and after (heavy line) application of a cork-foil shield over the parietal eye. Temperatures of the control (*Sphenodon* "S") before and after attachment of a similar shield in front of the "eye". Note that the differences in shape of the frequency curves of the temperatures of the two animals remain approximately the same after attachment of the shields.

the early part of the experiments. During this period the animals were probably seeking a means of escape. After about 6 weeks, movements had become stabilized and little change occurred in the overall average amount of travel, although there was considerable variation from day to day. The mean range in movement for the two animals during the period of stability was "L", 1.87 feet per hour (range .59 to 3.47 feet) and "S", 2.24 feet per hour (range .40 to 4.94 feet).

The daily pattern of movement involved long periods of quiescence, at times lasting

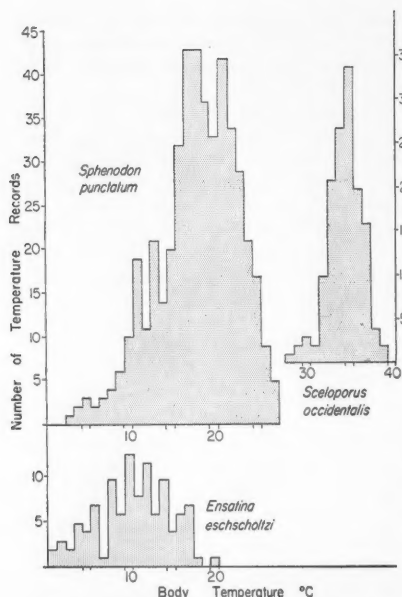


Fig. 3. Diagram to show the approximation of body temperatures of *Sphenodon* to those of a terrestrial salamander. A heliothermic lizard is included as representative of a stenothermic reptile with high thermal preferences. The salamander and lizard temperatures are of individuals abroad on the surface of the ground and capable of locomotion. All temperatures of *Sphenodon* were recorded in the laboratory (see text).

TABLE II  
REACTIONS OF *SPHENODON* TO LIGHT IN A  
PHOTOTHERMAL GRADIENT

	Total number of observations	Total points possible*	Points scored	Percentage of total points	Percentage increase in exposure to light
<i>Sphenodon</i> "L"					
Parietal eye exposed	149	894	99	11.1	
Parietal eye covered	107	702	213	30.3	273
<i>Sphenodon</i> "S"					
Head without cork-foil disc	124	744	112	15.1	
Cork-foil disc attached anterior to parietal eye	107	642	275	42.8	283

\* See text for method of scoring

as long as 5 hours. Movements were probably incited by hunger, thermoregulatory adjustments and handling.

## DISCUSSION

Accidental death of *Sphenodon* "S" terminated the experiment. It would have been desirable to compare the behavior of the two animals over a longer period than was possible. Two months may have been insufficient time for a marked behavioral change to occur. Although in laboratory experiments with lizards, a response to blockage of the parietal eye with foil was evident within a week, a reptile with a low metabolic rate like *Sphenodon* would probably respond more slowly. Experiments should be performed with younger individuals. In hatchlings a relatively large well defined transparent parietal eye "cornea" is clearly evident externally. In older animals translucency of the overlying skin is reduced and there is no definite "cornea". Perhaps with aging there is decline in parietal eye function.

Dendy (1910) felt that on the basis of structure there could be no formation of definite images by the parietal eye of *Sphenodon* but that the organ was well adapted for the perception of variations in intensity of light. He accepts Nowikoff's (1910) suggestion that the "eye" may be of use in warning a sleeping reptile of the approach of flying enemies. In view of the findings of Young (1935) on lampreys, Oksche (1955, 1956) on frogs, and Eakin's and my observations (1958) on lizards, it seems unlikely that the parietal end organ functioned in this manner. There is no evidence that any living vertebrate is frightened by a sudden change in the illumination reaching the parietal organ. On the contrary, attempts to stimulate locomotory movements in ammocoetes, lizards, and *Sphenodon* by illuminating the parietal eye have failed.

If the median eye of *Sphenodon* is functional, and on morphological and histological grounds this seems likely, it probably influences not so much somatic as visceral functions. In support of this suggestion it should be pointed out that the parietal eye nerve connects with the habenular complex. The possibility should be explored that the parietal eye of the tuatara, in response to solar radiation, influences metabolism and such autonomic functions as the regulation of blood pressure and the respiratory rate. A change in rate of metabolism in a cold blooded animal can be achieved readily by modification of its reaction to sunlight.

The suggestion that the median "eye" serves to warn of the approach of a flying enemy seems doubtful on other grounds.

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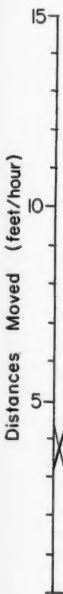


Fig. 4. cork-foil and an

whether a visual response to illuminating a predator in interfluctuating organ bpresumably kannem Welles, fectual require intensit would c

Judging from the widespread occurrence and prominence of pineal foramina in ancient vertebrates, it is evident that the "eye" was an important organ long before the appearance of birds, and probably most of the median-eyed vertebrates that were contemporaneous with pterodactyls were immune to the attacks of these flying reptiles. In view of the experimental evidence derived from vertebrates as different as lampreys and lizards, a question is raised as to

The frequent absence of the parietal eye nerve has offered difficulties for the theory of visual reception and has been a basis for considering the parietal eye a vestigial organ. If, however, the eye responds to photothermal changes, no nerve is required for transmitting images to the brain. A secretory response would serve to register such changes. Dendy (1910) has described secretory activity of the lens and retina of the parietal eye of *Sphenodon* and I have histological

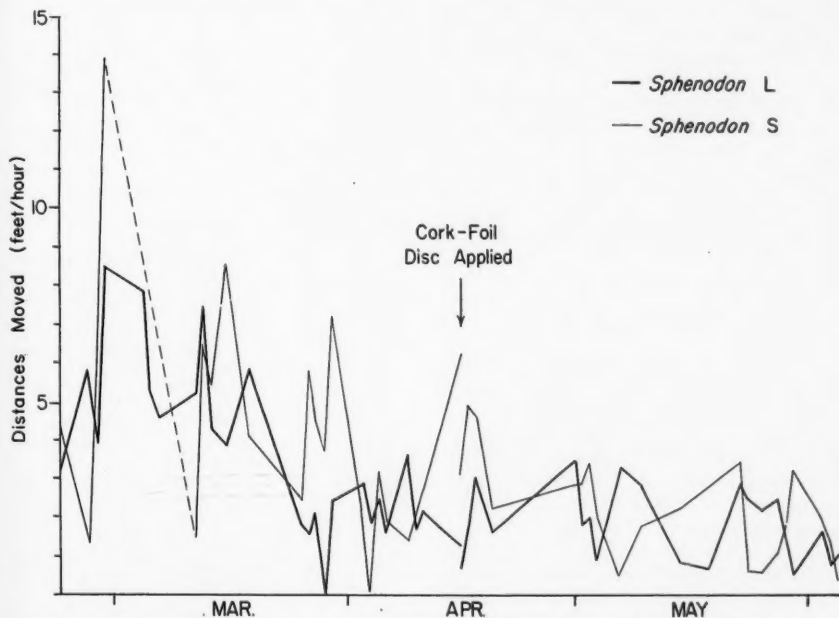


Fig. 4. Movements of tuataras in a photothermal gradient, before and after application of a cork-foil shield to the head. The shield was placed over the parietal eye of *Sphenodon* "L", and anterior to the "eye" of *Sphenodon* "S".

whether the "third eye" ever functioned as a visual receptor. If we regard the "eye" as responding not to the rapid changes in illumination due to the overhead attack of a predator, but rather to seasonal changes in intensity and duration of sunlight and to fluctuations due to weather, facts difficult to explain on the theory that it is a visual organ become intelligible. For example, the presumably deeply recessed "eye" of the kannemeyeriid dicynodonts (Camp and Welles, 1956: 267), in location seemingly ineffectual in watching a threatening sky, would require no great breadth of view as a solar intensity detector. A small patch of sky would do.

indications of a parietal eye secretion in lizards. The presence of pigment masses in the lens and chamber of the parietal eye, reported in *Sphenodon* and *Varanus* and considered as further evidence of parietal eye degeneration, poses no problem to the present theory of function.

#### SUMMARY

The reactions to light and heat of two tuataras were tested in photothermal gradients in the laboratory. After two months of preliminary testing the parietal eye of one animal was covered with cork encased in aluminum foil. A similar shield was attached anterior to the "eye" of the control

animal. Subsequent observation for a period of two months revealed no change in reactions to temperature and light in the parietal eye covered individual. The relative activity of the two animals, as determined by amount of movement in the experimental chambers likewise remained unchanged. The results stand in contrast to the behavior of lizards tested. In them blockage or removal of the parietal eye was followed by increased movements and exposure to sunlight or artificial illumination in the laboratory. The results suggest that either the parietal eye in tuataras of the size tested does not respond in the same manner as that of lizards, or there is a greater lag in this response. In view of the low metabolic rate of *Sphenodon*, two months may be insufficient time to obtain results.

The tuataras voluntarily occurred at temperatures ranging from 3.5 to 27.9°C. (mean 18.3°C.) in the thermal gradients. The critical minimum was found to be approximately 3 to 4°C.

#### ACKNOWLEDGMENTS

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in permitting the use of these valuable reptiles for this research.

Mr. Eugene Christman prepared the illustrations and Mr. Daniel Wilhoft helped in the care of the animals and in recording observations.

Mr. Charles Bogert and Dr. Richard Zweifel of the American Museum of Natural History loaned a preserved juvenal tuatara for study of the external morphology of the parietal eye.

Dr. Richard M. Eakin offered helpful suggestions on the manuscript.

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## Seasonal Variation in the Teeth of the Two-Lined Salamander

MARGARET McBRIDE STEWART

PREVIOUS investigators have observed a remarkable seasonal change in dentition of adult male northern two-lined salaman-

ders, *Eurycea bislineata bislineata* Green. Noble (1929; 1931) and Bishop (1941) stated that from October to May, adult males have

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long monocuspid teeth, directed forward, in both jaws. Females have shorter bicuspid teeth. Little is known of these changes in *Eurycea*. Noble and Pope (1929) experimented with another plethodontid salamander, *Desmognathus fuscus*, to determine the effect of hormones on tooth form. Castration produced reversal of the premaxillary teeth from the long, monocuspid male type to short, bicuspid teeth of the female type. When testicular transplants were made in castrated *D. fuscus* males, the teeth again became monocuspid (Noble, 1926; Noble and Davis, 1928). Noble implied that an individual tooth can hypertrophy from the bicuspid type to the monocuspid type rather than the change being effected by means of tooth replacement.

The present study was undertaken to investigate this supposed seasonal fluctuation in tooth form in *Eurycea b. bislineata* and to determine to what measurable degree it is expressed in individuals collected at different seasons. The dentition is polyphyodont and essentially homodont in spite of minor variations in tooth size and form. Larval teeth are long, straight, with a single, sharp cusp. As the animal approaches metamorphosis, monocuspid teeth are replaced by those of the bicuspid type. The teeth, having a distinct enamel cap, are curved slightly inward. In specimens collected at the time of transformation both types of teeth are present, the replacements being bifid. As males approach their first breeding season, the short bicuspid dentary, maxillary, and premaxillary teeth are replaced by longer, pointed teeth with a single cusp. These long, monocuspid teeth protrude slightly forward in the premaxillary group, and are straight, rather than curved inward, in the other groups. Vomerine and parasphenoid teeth show no change in either sex, but retain the short, bicuspid condition. Monocuspid teeth are retained in mature males.

It is a pleasure to acknowledge the contribution of Dr. William J. Hamilton, Jr., for his suggestion of the problem and for his constant encouragement. Dr. Howard E. Evans also gave many helpful suggestions. The field work was supported, in part, by the New York State Museum and Science Service.

**METHOD OF STUDY.**—Teeth of 145 specimens were examined. Collections were made in the Ithaca, New York, area at two-week intervals over a period of two years. Specimens were prepared as alizarin transparencies in the manner prescribed by Evans (1948). The animals were killed in chlorotone and fixed in

3% formalin for at least one month prior to partial clearing in 3% potassium hydroxide. When body tissue neared translucence, specimens were stained with alizarin red S; clearing was then completed in glycerine. With the exception of enamel, which remained transparent and colorless, the teeth stained red. Even minute replacements forming within the tissue were visible. A few teeth became dislodged due to the macerating action of the potassium hydroxide, but error introduced by this artificial loss was thought negligible. A 45-power binocular microscope was used for examination of the teeth, and measurements were made with the aid of an ocular micrometer.

The main concentration of study was on premaxillary teeth of breeding adults. They seem to reflect a greater differential development under hormonal control than do other tooth types (Noble, 1927). Teeth of a few subadults, metamorphosing individuals, and larvae of various sizes were examined for comparison. The height and basal width of the most anterior premaxillary teeth were recorded as an index for comparison between sexes and for detection of any possible seasonal changes. "Height" is the distance from the free border of the maxillary bone, the dental lamina, to the tip of the tooth crown when viewed laterally at a 90° angle. Tooth "width" is the distance from one side of the base of the tooth pedestal to the other when viewed directly from above the crown of the tooth. The tooth pedestal is a thickened raised ring, resembling an alveolus, forming the junction between the tooth and the jaw bone.

**TOOTH DEVELOPMENT.**—The youngest specimens examined, approximately one year old, measured 33 mm. in total length, and 19 mm. in snout-vent length. At this age teeth were straight, sharp, monocuspid, and relatively long (113–135 microns) for the small size of the animal. Monocuspid replacements were present, arranged regularly to move into position when an adjacent tooth was lost. Dentary, premaxillary and vomerine teeth were well formed, the dentary being in the most advanced stage of development. Maxillary and parasphenoid teeth were not yet present. The two vomerine tooth patches (plus those on the pterygoid) each formed an elongated semicircle, open posteriorly, one on each side of the midline. At this stage, the lateral arm of each patch projected farther posteriorly than did the medial arm. This situation is reversed in the adult due to the disintegration of the laterally-lying pterygoid and the migration of the medial arm of the vomer posteriorly to

form the parasphenoid tooth patch. In plethodontids, two dentigerous processes of the combined prevomers and palatines are carried posteriorly and overlie the parasphenoid to form a patch of tooth-bearing bone (Wilder, 1920; 1925).

those appearing first were noncuspid, but soon all were replaced by bicuspid teeth. Many of the ankylosed dentary, premaxillary and maxillary teeth were bicuspid, the lingual cusp the longer. Replacements were also bicuspid.

Both male and female subadults had the

TABLE I  
TOOTH VARIATION IN MALE AND FEMALE *Eurycea bislineata bislineata*  
Means and ranges for the functional teeth only are given (empty sockets not included).

Structures measured	Adults				Subadults			
	Males n = 59		Females n = 27		Males n = 20		Females n = 12	
Snout-vent length (mm.)	36.7 (30.2-45.3)		38.4 (31.5-43.2)		32.9 (27.3-39.5)		31.7 (27.3-37.2)	
Distance between jaws (microns)	429 (225-765)		303 (135-400)		—		—	
Premaxillary teeth								
Number	5 (2-9)		8 (5-12)		9 (6-12)		9 (7-11)	
Height (microns)	284 (180-495)		151 (113-180)		—		—	
Width of pedestal (microns)	158 (135-225)		93 (67-135)		—		—	
No. replacements	5 (3-9)		9 (6-10)		8 (3-13)		8 (6-9)	
	Right	Left	Right	Left	Right	Left	Right	Left
Maxillary teeth (no.)	11 (8-12)	13 (8-17)	14 (10-18)	13 (11-15)	—	—	—	—
Dentary teeth (no.)	14 (9-22)	16 (13-19)	18 (9-22)	17 (12-20)	—	—	—	—
Vomerine teeth (no.)	5 (2-8)	5 (2-8)	5 (0-9)	5 (0-8)	5 (4-8)	5 (3-9)	6 (4-8)	5 (4-7)
Parasphenoid teeth (no.)	46 (28-70)	46 (30-77)	46 (24-68)	47 (23-67)	42 (29-57)	41 (31-56)	37 (34-41)	33 (31-35)

As growth progresses, the maxillary bone calcifies, but not until after the maxillary teeth are already formed. In Caudata, teeth form before the supporting bones; the opposite condition exists in Salientia (Noble, 1931). In the present series, at metamorphosis all jaw elements had formed but were not fused. Vomerine patches had taken their position and parasphenoid patches, now separate from the vomerines, had moved into place. Parasphenoid teeth were becoming numerous;

normal adult bicuspid teeth, similar in form in each tooth patch. In all metamorphosed salamanders, bifid teeth occur except where the teeth have been secondarily elongated or lost (Noble, 1927). All teeth were slightly recurved. Vomerine and parasphenoid teeth were curved slightly postero-laterally.

Data from tooth counts and measurements are summarized in Table I. Only functional teeth were considered, i.e., empty sockets were not included in totals. Mean snout-vent

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length for each group is given. No significant difference was noted between numbers of teeth on right and left sides of any tooth complement, nor between numbers in sub-adult males and females. The position of tooth patches in the roof of the mouth of an adult male is shown in Figure 1.

**VOMERINE TEETH.**—The mean number of vomerine teeth was five per side (range: 0-8). Previous investigators have reported slightly different numbers. Bishop (1941) gave the range as 7-12 in females; 7-10 in males. Hilton (1951) found eight to be the average. Behind each single row of functional teeth on both right and left prevomers, there was an irregular row of replacements. From the small number of replacements present at any one time, the author assumed that replacement is not so rapid in this group of teeth as it is in the parasphenoid and jaw patches. The vomerine and parasphenoid series were not always separate as indicated by Bishop (1941). One adult female examined lacked vomerine teeth entirely. A few other individuals had teeth scattered between vomerine and parasphenoid patches; in another, the vomerine patch was continuous with the parasphenoid patch. Gordon (1935) reported a similar situation in some specimens of *Eurycea longicauda guttolineata*. This could be an atavistic expression in certain individuals since vomerine and parasphenoid tooth patches have not separated in primitive salamanders (Dunn, 1926).

**PARASPENOID TEETH.**—Considerable variation in number of parasphenoid teeth was exhibited by individuals examined (mean: 46; range: 23-77 per patch). Teeth were arranged in one to five longitudinal rows, the number of rows decreasing anteriorly. Teeth in one row were in positions alternating with teeth in the next row. The median rows were ankylosed to the supporting bone in a manner similar to that of the jaw teeth. The actual manner of replacement of the innermost rows was not determined. Either there was disintegration of the median edge of the denticulous bone patch with a continuous rebuilding of bone laterally, or else the replacement teeth moved over the outer functional rows to replace those teeth from the innermost rows in each patch. Three to five rows of replacement caps were visible in epithelial tissue adjacent and lateral to the denticulous patch. The greater the number of rows of functional teeth, the greater was the number of rows of replacements. There seemed to be a suggestion of an increase in number corresponding

to an increase in size and age of the animal, but this was not consistent in all individuals examined.

**MAXILLARY AND DENTARY TEETH.**—Maxillary and dentary teeth are similar in form except for a gradual decrease in height and size posteriorly. The most posterior teeth are approximately one-fourth the size of the most anterior ones. There were fewer teeth in adult males than in adult females (Table I).

In 30 percent of the adult males examined, a few of the most posterior maxillary and

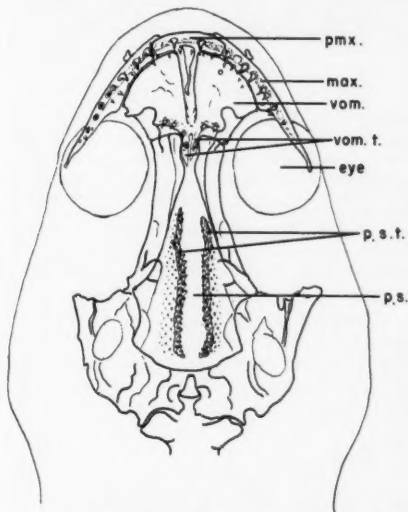


Fig. 1. Ventral view of the skull of an adult male *Eurycea b. bislineata* showing tooth patches.  $\times 14$ . Collected May 21, 1955. Max., maxillary bone; pmx., premaxillary bone; p.s., parasphenoid bone; p.s.t., parasphenoid teeth; vom., vomerine bone; vom. t., vomerine tooth patches.

dentary teeth retained the bifid condition even though all other teeth were monocuspid. Any of the five most posterior teeth might be bifid. At no time during the year did all males exhibit a complete reversal from bicuspid to monocuspid tooth form.

**PREMAXILLARY TEETH.**—There were fewer functional premaxillary teeth in males than in females (mean number in males, 5; in females, 8). This difference is significant at the five percent level ( $t = 2.09$ ; d.f. = 84). Premaxillary teeth in males were significantly longer and larger than corresponding teeth of females (Fig. 2, A and B). Although this difference in length was most pronounced in the median premaxillaries, difference in length, size, and number of teeth between

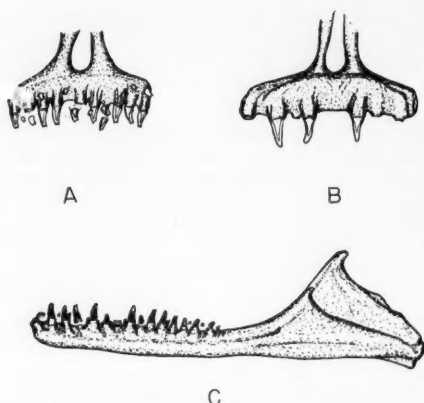


Fig. 2. Premaxillary and dentary tooth complements of *Eurycea b. bislineata*. A, lingual view of the tooth-bearing portion of the premaxillary bone of an adult female collected May 21, 1955.  $\times 51$ . B, lingual view of the tooth-bearing portion of the premaxillary bone of an adult male collected July 5, 1955.  $\times 51$ . C, left lateral aspect of the lower jaw of an adult male collected June 30, 1955.  $\times 34$ .

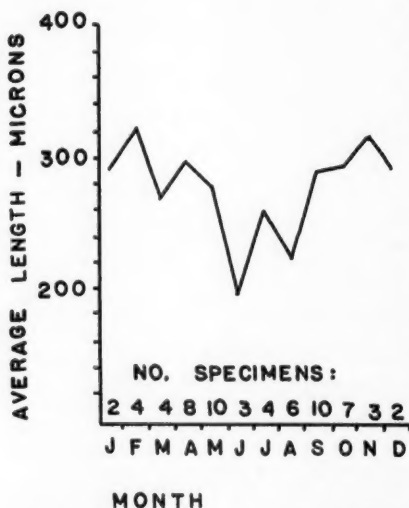


Fig. 3. Seasonal variation in average length of premaxillary teeth in male *Eurycea bislineata* *bislineata*.

the sexes was consistent throughout most of the jaw teeth (Table I). Only two males had premaxillary teeth as short as the longest premaxillaries in the females (180 microns). Premaxillaries in males averaged 133 microns longer than those in females. In neither males

nor females was there significant correlation between height of teeth and snout-vent length of the animal.

**SEASONAL CYCLE OF TOOTH FORM.**—There was no evidence of any cyclic changes in structure or size of teeth in females, but considerable variation was noted in teeth of males throughout the year (Fig. 3). The greatest tooth height occurred in those animals collected during the breeding season (288–321 microns); shortest teeth (195–255 microns) were present during June, July, and August, the interim period in the sex cycle.

At the end of the breeding season, from the end of April to the middle of June, there was a marked loss of teeth in both upper and lower jaws (Fig. 1 and 2B). This was particularly noticeable in the premaxillary complement where there were often only two to four teeth present. In one specimen, taken June 15, there were only six functional teeth in the lower jaw. This edentulous condition was observed in 30 percent of the adult males collected during May, June, July, and August, tooth gaps becoming less numerous after June. Since replacements backing tooth gaps were often very small, and since most specimens taken over a period of two months exhibited tooth loss, it is thought that the edentulous condition is maintained over a period of several weeks. It was not exhibited in vomerine and parasphenoid patches.

After the middle of June, when most males showed replacement of the edentulous patches, there was a strong tendency for those replacements to be bicuspid. This was not true of all replacements and at no time were all teeth bicuspid in adult males. Since about one-fourth of the teeth were monocuspid during the summer, the teeth at that time appeared quite irregular (Fig. 2C). Fewer bicuspid teeth were present anteriorly. In one specimen examined, every third tooth in the posterior and lateral maxillary group was monocuspid, those in between being bicuspid. Premaxillary teeth exhibiting the bicuspid tip were not so strongly bifid as were the maxillary and dentary teeth, nor was there a marked difference in height between premaxillary monocuspid and bicuspid teeth. In the anterior maxillary teeth, monocuspid teeth were 225 microns in height while adjacent bicuspid teeth were only 180 microns high. This difference was consistent.

By the middle of September, all males examined had a full complement of monocuspid teeth. There seemed to be considerable individual variation in the time of full

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replacement. Two specimens taken July 1 showed many large replacements moving in to fill the empty sockets; on the other hand, two individuals taken August 10 still had many bare patches on the jaw bone.

There was no evidence of a single tooth undergoing change from one type of cusp to another as was implied for *Desmognathus fuscus* (Noble and Davis, 1928). Considering the nature of the teeth and the frequency of replacement, change of an individual tooth seems quite unlikely. In the late spring, many of the large maxillary and premaxillary teeth in both sexes appeared worn, the tips almost flat in some individuals, and very dully rounded in others. This might be an indication of few replacements occurring during the winter and spring when much of the animal's energy is directed toward reproductive activity.

**TOOTH REPLACEMENT.**—The number of replacements associated with the premaxillary bone averaged the same as the number of functional teeth. This is misleading in that it would seem to imply that there was one replacement for each tooth. This was not the case. Many tooth positions lacked visible replacements altogether while others were backed by as many as three replacements. No attempt was made to determine the actual replacement pattern and frequency, but certain facts were evident. Replacements were either directly back of a functional tooth or were in a position alternating with functional teeth. In many individuals, three distinct rows of replacements were visible. These were of three different sizes, the smaller caps farther from ankylosed teeth. The size of the caps was not always consistent with the position. An extremely small replacement cap might be directly adjacent to a functional tooth which showed no signs of disintegration. Ankylosing teeth could be distinguished from teeth which were in the process of falling out. If a tooth were becoming affixed to the jaw bone, the tooth pedestal was entire. A clear layer was visible between the tooth and the pedestal or at the edges of the tooth where the dentine was not thoroughly formed. If a tooth were in the process of falling out, there was an obvious disintegration of the pedestal, or even part of the tooth. The amount of decalcification is dependent upon the stage of disintegration. The general process of tooth replacement for amphibians has been described by Tomes (1923).

Gillette (1955) stated that resorption of the

old tooth, in *Rana pipiens*, occurs in conjunction with eruption of succeeding teeth and may be dependent upon it; preparations may show teeth which have been resorbed down to the enamel tip. This was never observed in the species under consideration, although some tips might have been displaced by the fixative. If teeth fall out before complete resorption, it would seem likely that they might be swallowed and found in the stomach or intestines of the animal. Cleared intestinal tracts of 15 specimens were examined for such evidence, but no teeth were found.

The only clue to rate of replacement was evidence furnished by breeding males during the summer months. Most of the teeth had fallen by late May or June. By late June and July, some bicuspid teeth were present; replacements were also bicuspid. By late August, teeth were almost all monocuspid with monocuspid replacements. This would indicate at least two replacements during the three summer months. If this rate were constant throughout the year, a tooth position might be filled at least eight times during the year. However, in late spring, teeth in both males and females appeared quite worn, as if there had been considerable use of a single tooth set. This may indicate little replacement during the winter months.

**DISTANCE BETWEEN JAWS.**—In adult males the upper jaw protrudes beyond the lower jaw to a much greater degree than in females. This is an index of the length of the upper jaw which is longer in adult males than in females. The distance between the most anterior points of the upper and lower jaws, when viewed ventrally, was measured. This distance averaged 126 microns greater in males than in females. This secondary sex character could be a modification to adapt to the longer teeth of the males, the longer jaw allowing for overlap rather than occlusion of the premaxillary teeth. Immature animals showed little or no difference in lengths of upper and lower jaws.

**SIGNIFICANCE.**—No evidence was obtained from this study which provides any explanation for the differences in premaxillary teeth between male and female salamanders. Changes in the male teeth are obviously controlled by the testosterone level since they are correlated with changes in the testes. Some investigators have attributed these tooth differences to "neutral" characters somehow linked to genes influencing secondary sex characters, but no longer having

a function. Others question the existence of any useless characters. If the latter is true, then further observation may reveal some adaptive significance for tooth changes in males. Since many male plethodontid salamanders have elongate, monocuspid teeth (Noble, 1931), it would seem that such a widespread character would surely have some reason for being. It has been suggested that the longer teeth in males serve to stimulate the females during courtship in *Hydromantes platycephalus* (Noble, 1931). As yet, there is no evidence for such a situation in *Eurycea b. bislineata*, but since the entire mating behavior has never been observed, no statement can be made as to its use in this respect.

The effect, if any, of the edentulous condition in males was not determined. An analysis of stomach contents of the animals during this time might reveal some differential preferences in food items. If teeth are used at all for capturing or chewing prey, it seems that the lack of teeth for such a long period would surely influence feeding habits of the animal. Considerable study must be done before these questions can be answered.

#### SUMMARY

Seasonal fluctuation in tooth form in male *Eurycea b. bislineata* is described from alizarin transparencies. Numbers of teeth in all tooth patches were recorded. The most anterior premaxillary tooth was used as an index for comparison.

Maxillary and dentary teeth were larger and less numerous in males than in females. Males averaged 24 maxillary teeth; females 27. The average number of dentaries was 30 in males; 35 in females. Fewer functional premaxillary teeth were present in males (5) than in females (8) and were significantly longer and wider in males.

Teeth of females exhibited no cyclic change, but considerable variation was noted in teeth of males throughout the year. Premaxillary teeth were longest (288–321 microns) during the breeding season and shortest (195–255 microns) during the summer months, the period of spermatogenesis. Average height of premaxillary teeth in females was 151 microns. At the end of the breeding season, males exhibited a marked loss of teeth in both jaws. Loss was greatest in the premaxillary complement. Many replacements moving into these spaces were bifid. However, by the middle of September,

the beginning of the breeding season, all males examined had a full complement of monocuspid teeth, these being maintained throughout the winter. The purpose of the elongate, monocuspid teeth present in males during the breeding season was not determined.

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# Hybridization and Larval Development in *Rana palmipes* Spix

E. PETER VOLPE AND SUZANNE M. HARVEY

**R**ANA *palmipes*, described from specimens collected in Brazil (Spix, 1824), constitutes the only representative of the genus in South America (Boulenger, 1920). Frogs occurring in Central America and lower Mexico that closely resemble the Brazilian *palmipes* have been assigned to this species. Whether all frogs presently recognized as *R. palmipes* are members of a single polytypic species awaits analyses of populations throughout the geographic range. *R. palmipes*, as currently understood, extends northward into central Veracruz and the Tehuantepec region of Oaxaca in Mexico (Zweifel, 1954).

*R. palmipes* has been considered as a lowland form, inhabiting quiet waters (Stuart, 1948; Zweifel, 1954). Certain species in Middle America have been surmised to be upland derivatives of *palmipes*. Stuart (1948) suggested that *R. macroglossa*, found at high elevations in Guatemala, El Salvador and western Honduras, is a montane offshoot of *palmipes*. Taylor (1938) stressed the close relationship of *palmipes* to the mountainous form, *R. sierramadrensis*. Zweifel (1954) regarded *palmipes*, *sierramadrensis*, *macroglossa*, and *sinaloae* as comprising the *palmipes* species complex in Mexico and Central America.

Pertinent to the present study is the description by Stuart (1951) of the larva of the stream-dwelling *R. macroglossa*. The larva is apparently stream-adapted, as judged by its flattened body, reduced tail fins, and high labial count (6/4). Its presumed lowland counterpart, *R. palmipes*, might be expected to have pond-type larval characteristics, namely, full body, arched dorsal fin, and low labial count. Breder (1946) has presented diagrams, unaccompanied by a description, of tadpoles assumed to be *R. palmipes* collected from the Rio Chucunaque drainage at Darien, Panama. The tadpole is not streamlined, nor, as far as can be ascertained from the drawing, is the labial count high.

On September 8, 1956 the senior author, accompanied by Norman C. Negus and John De Abate, encountered a breeding aggregation of *R. palmipes* in the stagnant backwater of a tributary of the Pejibaye River near the Hacienda Yolanda, Cartago

Province, Costa Rica. Adults<sup>1</sup> and larvae were collected and brought back alive via air to the Tulane University laboratories. The larvae were examined in the living state (narcotized in M. S. 222, Sandoz Chemical Company, New York City) and subsequently preserved in 10 percent formalin. The parentage of these larvae was verified by examination of laboratory-reared larvae derived from experimental matings of *palmipes*. The larvae of *palmipes* from Costa Rica were then compared with those from Mexico, Guatemala, Panama, and Colombia, and with those of *R. macroglossa* from Guatemala.

In addition, hybridization experiments were performed involving *R. palmipes*, *R. clamitans*, and *R. pipiens*. The conspicuous anterior green coloration (in life) of adult *palmipes* prompted the attempt to cross-fertilize *R. palmipes* with the North American green frog.

The results of these studies are reported herein.

## LABORATORY HYBRIDIZATIONS

The method of artificial fertilization was employed in the laboratory hybridization experiments. Ovulation was induced by the standard pituitary injection procedure (Rugh, 1934). A sperm suspension was prepared by macerating a pair of testes in 20 cc. of 0.10 Ringer's solution. Four series of artificial crosses were performed. In the first series, the eggs of a single *palmipes* were stripped into five different sperm suspensions. The males employed in the first series, the parents involved in the other three series, and a summary of the results are given in Table I. Leopard frogs from Oshkosh, Wisconsin and the Lake Champlain district of Vermont were obtained from professional dealers; those from Moravia de Chirripo, Costa Rica were collected by the senior author and his aforementioned colleagues on September 9, 1956. Green frogs from Englewood, New Jersey were provided by J. A. Moore; those from Chalmette, Louisiana

<sup>1</sup> The features of the adults compare favorably with those described by Taylor (1952, 1954) of *R. palmipes* from Turrialba, Costa Rica. The Costa Rican *palmipes* has been designated as a subspecies, *R. p. hoffmanni*, by Müller (1923) who lists the type locality as simply "Costarica".

were furnished by H. Whitten of the Wau-bun laboratories.

The eggs of *clamitans* placed in a *palmipes* sperm suspension did not rotate or cleave,

TABLE I  
HYBRIDIZATION EXPERIMENTS

Series	Female Parent	Male Parent	Development of Embryos
1	<i>R. palmipes</i> (Costa Rica)	<i>R. pipiens</i> (Vermont)	Failure at gastrulation
		<i>R. pipiens</i> (Wisconsin)	Failure at gastrulation
		<i>R. pipiens</i> (Costa Rica)	Failure at gastrulation
		<i>R. clamitans</i> (Louisiana)	Failure at gastrulation
		<i>R. palmipes</i> (Costa Rica)	Normal
2	<i>R. palmipes</i> (Costa Rica)	<i>R. pipiens</i> (Vermont)	Failure at gastrulation
		<i>R. clamitans</i> (New Jersey)	Failure at gastrulation
3	<i>R. clamitans</i> (Louisiana)	<i>R. clamitans</i> (Louisiana)	Normal
		<i>R. palmipes</i> (Costa Rica)	Failure at fertilization
4	<i>R. pipiens</i> (Wisconsin)	<i>R. palmipes</i> (Costa Rica)	Failure at gastrulation
		<i>R. pipiens</i> (Costa Rica)	Relatively normal development*

\* See Volpe (1957a) for details.

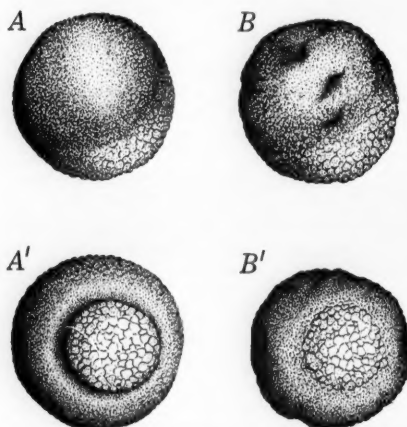


Fig. 1. Normal blastula (A) and normal gastrula (A') stages of embryos derived from the cross, *R. palmipes* ♀ X *R. palmipes* ♂; abnormal blastula (B) and pseudo-gastrula (B') stages of embryos of the cross, *R. palmipes* ♀ X *R. clamitans* ♂.

suggesting failure of sperm penetration. Embryos from the reciprocal cross, *R. palmipes* ♀ X *R. clamitans* ♂, developed normally during the early cleavage stages. External abnormalities were first evident in the late blastula stage. The surface of the animal hemisphere overlying the blastocoel became pitted (Fig. 1,B). Subsequent epibolic movements of the heavily pigmented animal hemisphere cells over the lightly colored vegetative cells led to the formation of a false yolk plug or pseudoblastopore (Fig. 1,B'). In the normal gastrula (Fig. 1,A'), epiboly was accompanied by involution or the inturning of animal hemisphere cells at the blastopore lips, encircling a plug of yolk. In contrast, the animal hemisphere cells of the hybrid gastrula did not infold but migrated over the vegetative cells, delimiting an area that simulated a yolk plug.

The pitting of the animal hemisphere with the subsequent formation of a false yolk plug was observed also in embryos derived from the cross of a *palmipes* female and a *pipiens* male (from Vermont, or Wisconsin, or Costa Rica). The gastrulation process was impeded in a different manner in embryos of the cross, *R. pipiens* ♀ X *R. palmipes* ♂. The epibolic movements were normal and a slight dorsal lip formed. However, no lateral or ventral blastopore lips developed and the embryos subsequently cytolized.

In essence, *R. palmipes* can not be hybridized successfully with either *R. pipiens* or *R. clamitans*. Indeed, the eggs of *R. clamitans* can not be fertilized by sperm of any of several ranid species thus far tested (see Moore, 1955).

#### LARVAE OF *R. palmipes*

The collection from Costa Rica consisted of 23 larvae, which were measured with a dial caliper and staged according to the system of Taylor and Kollros (1946). Two groups, with respect to size and stage, are recognizable (Table II). Fifteen larvae, constituting the first group, possess small, undifferentiated hind limb buds (stages III and IV) and range in size (snout to tail tip length) from 33.1 to 42.8 mm. Eight larvae of the second group exhibit more advanced development of the hind limbs (stages XI to XIX) and vary in size from 67.6 to 81.2 mm. The two groups probably represent larvae derived from separate matings at different breeding periods. The tail tips of

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most of the tadpoles have been mutilated, presumably by predators. In measuring and drawing the tails, the tips were reconstructed from perfect tails of laboratory-reared larvae. The latter were derived from the experimental cross, *palmipes* ♀ X *palmipes* ♂ of Series 1 (Table I). The experiment was terminated after obtaining and examining the late embryonic stages (23–25) and the early larval stages (I–III).

lower, and second lower ridges bear a few teeth. The inner edges of the horny beaks are pigmented and serrated. At stage 25, the lateral papillary fringes are emarginate and contain small papillae. Teeth are conspicuous on the third lower labial ridge.

The labial tooth formula of a larva at stage I (defined in Taylor and Kollros, 1946) is 2/3 as shown in Fig. 2A. The second upper and third lower tooth rows are weakly

TABLE II  
TOOTH-ROW FORMULAS DURING LARVAL DEVELOPMENT<sup>1</sup>

	<i>Rana palmipes</i>							<i>Rana macroglossa</i>
	Costa Rica	Colombia	Panama	Guatemala	Mexico (Chiapas)	Mexico (Oaxaca)	Mexico (Vera Cruz)	Guatemala
Limb Bud Stages								
I	2/3 <sup>2</sup>	—	4/4	—	—	4/4	—	—
II	3/4 <sup>2</sup>	4/4	4/4	—	—	3/4, 4/4	—	5/4
III	4/4	4/4, 5/4	4/4, 5/4	—	5/4	3/4, 4/4	—	6/4
IV	4/4	5/4	5/4	—	5/4	5/4	—	6/4
V	—	5/4	5/4	—	—	4/4, 5/4	—	5/4, 6/4
Paddle Stages								
VI	—	—	5/4	4/4	5/4	4/4, 5/4	—	6/4
VII	—	—	5/4	4/4	—	4/4	—	6/4
VIII	—	—	5/4	—	—	5/4	—	6/4
IX	—	—	5/4	4/4	—	—	—	6/4
X	—	—	5/4	4/4	5/4	5/4	—	6/4
Foot Stages								
XI	4/4	5/4	5/4	—	—	5/4	—	5/4, 6/4
XII	4/4	—	5/4	—	—	—	4/4	6/4
XIII	4/4	—	5/4	—	—	—	4/4, 5/4	5/4, 6/4
XIV	—	—	—	—	—	—	4/4, 5/4	6/4
XV	4/4	—	—	—	—	—	5/4	6/4
XVI	—	—	—	—	—	—	5/4	5/4, 6/4
XVII	4/4	—	—	—	—	—	4/4, 5/4	6/4, 7/4
Metamorphic Stages								
XVIII	—	—	—	—	—	—	—	—
XIX	3/4	—	4/4	—	—	—	—	6/4
XX	—	—	—	—	—	—	Resorption	Resorption

<sup>1</sup> Tooth-row formulas are indicated only for those stages represented in the samples.

<sup>2</sup> Laboratory-reared larvae.

The larvae exhibit typical ranid features: sinistral spiracle, dextral anus, papillae present on the bottom of the lower labium, and eyes situated more dorsally than laterally. Distinctive features are the labial tooth formula and the melanophore pattern of the tail.

**MOUTHPARTS.**—The mouthparts differentiate during the closing stages of the embryonic period. Cornified frameworks of the beaks and rudiments of the papillary fringes are evident at embryonic stage 23 (defined in Shumway, 1940). Labial ridges are recognizable at stage 24; the first upper, first

differentiated. Teeth in the third upper labial ridge appear either before or simultaneously with those of the fourth lower tooth ridge. Both conditions have been observed in larvae approaching stage II. The 3/4 tooth pattern of a tadpole at stage II is illustrated in Fig. 2B. The fourth upper tooth row is the last to develop, becoming evident in larvae at stage III.

The mouthparts of a larva at stage XII, illustrated in Fig. 2C, are characteristic of *palmipes* between stages IV and XVII. The labial tooth formula is 4/4. The first tooth row in the upper labium is continuous; the

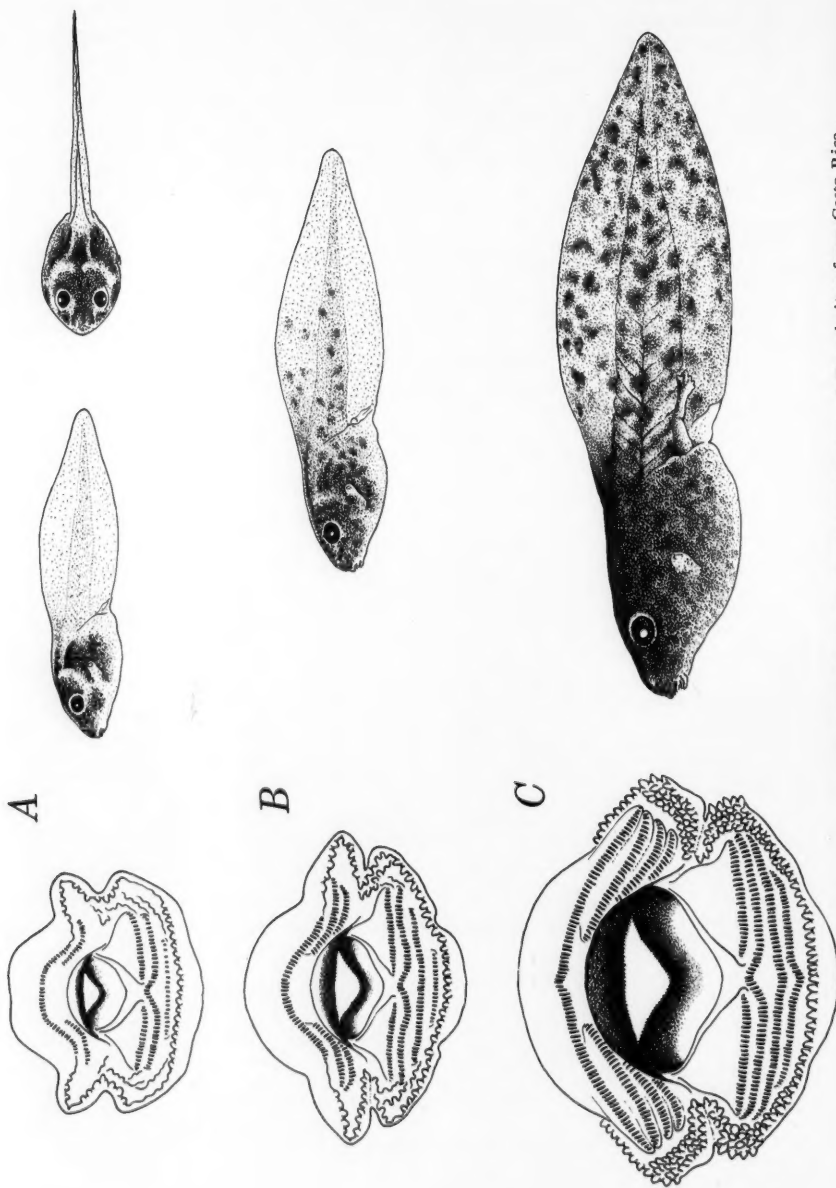


Fig. 2. Stages I (A), II (B), and XII (C) in the larval development of *R. palmipes* from Costa Rica.

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other upper tooth rows are divided. The second to fourth upper tooth rows decrease in length posteriorly, following the contours of the broadly U-shaped upper beak. The median space of the second upper tooth row is 0.50 to 0.75 times the length of either lateral segment of teeth. On either side, the third upper tooth row is approximately two-thirds the length of the second; the fourth is about three-fourths the length of the third.

The first lower tooth row is interrupted medially by a short space; the other lower tooth rows are continuous. The second lower tooth row rises to a point in the midline in

having been resorbed. The third upper and fourth lower tooth rows are shortened considerably, and the papillae are reduced in size. The ontogenetic changes in the tooth pattern are summarized in Table II.

**MELANOPHORE PATTERN OF THE TAIL.**—Two types of melanophores, filamentous and dendritic, are prominent in the tail. The filamentous melanophores (Fig. 3A), clearly discernible microscopically, are densely distributed in the superficial epidermis. In the living tadpole, the tail fins are rendered cloudy by the closely spaced filamentous melanophores. Color changes (shade differences) depend primarily upon the degree

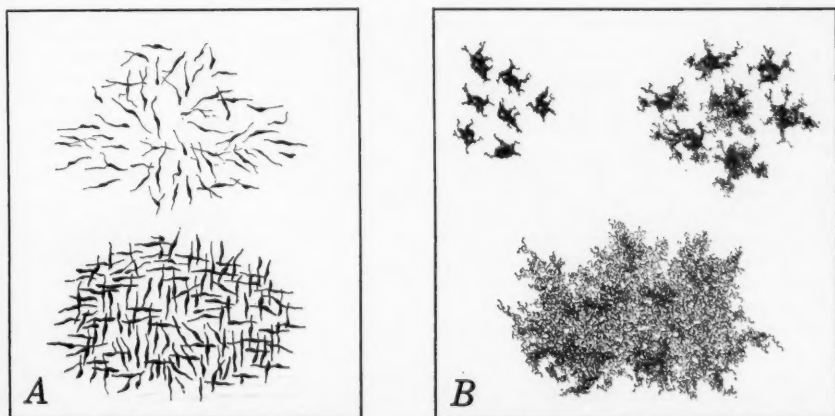


Fig. 3. (A) Nature and arrangement of epidermal filamentous melanophores in the tails of larvae of *R. palmipes* from Costa Rica (top) and Colombia (bottom). (B) Three different appearances of a "spot" (aggregations of dermal dendritic melanophores) in the tails of larvae of *R. palmipes* from Costa Rica, depending upon the degree of dispersion of pigment in the individual melanophores.

the direction of the broadly V-shaped lower beak. The first three lower tooth rows are essentially equal in length. The fourth corresponds in outline to the third but is 0.2 to 0.3 shorter than the third in larvae between stages IV and XVII.

Each lateral fringe bearing the papillae is folded inward between the upper and lower tooth rows. Marginal papillae are present along the sides of the upper and lower labia and continue uninterrupted along the bottom of the lower labium. Numerous irregularly arranged papillae are clustered inside the emarginated regions of the lateral papillary fringes.

The larva at metamorphic stage XIX (just prior to the emergence of the forelimbs) has a  $3/4$  tooth formula, the fourth upper row

of concentration of pigment granules within the dermal dendritic melanophores. Three different states of dispersion of pigment are shown in Fig. 3B; in the fully dispersed state the boundaries of the individual dendritic melanophores are obscured. The complete dispersion of pigment results in a dark appearance of the surface of the tail as a whole.

The dermal dendritic melanophores occur singly and in clusters, the latter condition being responsible for the "spotted" appearance of the tail evident to the unaided eye (Fig. 2C). The dendritic melanophores are not congregated into "spots" in the tail of larvae at stage I (Fig. 2A). Aggregations of the dermal melanophores first occur in the anterior portion of the tail in larvae at

stage II (Fig. 2B). The "spots" in the tails of advanced larvae vary in size, number, and arrangement.

A dorsal view of the larva (Fig. 2A) illustrates the pattern of subdermal pigmentation in the head region. The deep-lying melanophores between and behind the eyes form a striking anchor-like pattern, i.e., a median bar with two curved arms. The dorsolateral area directly posterior to each "arm" is devoid of subdermal melanophores and consequently contrasts sharply with the pigmented regions. These two light curved areas become filled in with melanophores to a greater or lesser extent during the course of development.

#### COMPARISONS

As had been found in previous studies (Limbaugh and Volpe, 1956; Volpe, 1957b), the most satisfactory characters for comparative studies are the structure of the mouthparts and the melanophore pattern of the tail. These features are relatively constant as compared to measurements of various body components. Body dimensions not only change continuously during development but are highly variable at a given stage of development. Possible differences in the growth patterns of tadpoles from various localities are obscured by the large variations in several linear dimensions recorded. Moreover, the mutilated condition of many of the larvae and alterations due to the use of different preservatives or techniques of preservation cast doubt on the reliability of many of the measurements. It could be noted, however, that the tadpoles of both *palmipes* and *macroglossa* may be relatively large during the early stages of larval development. At stage II, a period in which the hind limb is a faintly visible bud, the snout-to-tail tip lengths may exceed 60 mm., as exemplified by larvae of *palmipes* from Colombia. Ribeiro (1922) commented in general terms on the large size of *palmipes* tadpoles from Brazil, and Mertens (1952) remarked that *macroglossa* larvae from El Salvador may reach 49 mm. in length before the hind limbs appear. Tadpoles of *macroglossa* from Guatemala examined in the present study range in size from 30 to 53 mm. during the "bud" stages of hind limb development (stages II-V).

Specimens examined are listed in the following order: locality, number of specimens from each locality, and (in parentheses) museum catalogue numbers. AMNH, CNHM,

MCZ, UMMZ, and USNM represent the American Museum of Natural History, Chicago Natural History Museum, Museum of Comparative Zoology (Harvard), University of Michigan Museum of Zoology, and the United States National Museum respectively. Observations and data on the mouthparts and pigment patterns of the tails are summarized in Table II and Figs. 4 and 5.

COLOMBIA, CHOCO DEPARTMENT, PIZARRO, 12 (CNHM 44126).—The tooth formula of *palmipes* larvae from the coastal city of Pizarro in Colombia is  $4/4$  at stage II, changes to  $5/4$  during stage III, and apparently remains at  $5/4$  during later larval development (Table II). The fifth upper labial row, however, is weakly differentiated, being represented in most specimens by a few teeth. Except for the additional short fifth upper row, the arrangement and relative lengths of the tooth rows are similar to those of *palmipes* larvae from Costa Rica. Both are characterized by a wide median space in the second upper labial row of teeth.

The melanophore pattern of the tail of the Colombia *palmipes* is strikingly different from that of the Costa Rica *palmipes* (cf., Figs. 2 and 5A). The tail is dark and opaque; both the musculature and fins are densely flecked with dermal dendritic melanophores. Thick epidermal filamentous melanophores occur throughout the tail and are arranged in fine meshes. The nature of the filamentous network is illustrated in Fig. 3A.

PANAMA, RIO SUCUBI, 1 (AMNH, 51766); CAMP CREEK, RIO CHUCUNAQUE, 14 (AMNH 51768), 28 (AMNH 51770), 6 + 1 VIAL OF EMBRYOS (AMNH 51772), 25 (AMNH 51781), 27 (AMNH 51795); THREE FALLS CREEK, 9 (AMNH 51806).—These series of tadpoles from the Rio Chucunaque and its tributaries in eastern Panama are part of the amphibian collections of the Marsh-Darien Expedition in 1924. The larvae were provisionally designated as *palmipes* by Breder (1946).

The ontogeny of the mouthparts is similar to that of *palmipes* from Colombia (Table II). The tooth formula is  $4/4$  during the early stages of larval development (stages I and II). A rudimentary fifth upper tooth row is present in several tadpoles at stage III, the identical period in which this row first appears in the Colombia larvae. The  $5/4$  tooth pattern is characteristic of larvae in the later stages of development (stages IV-XIII). The fifth upper row in advanced larvae is generally well-defined, consisting of

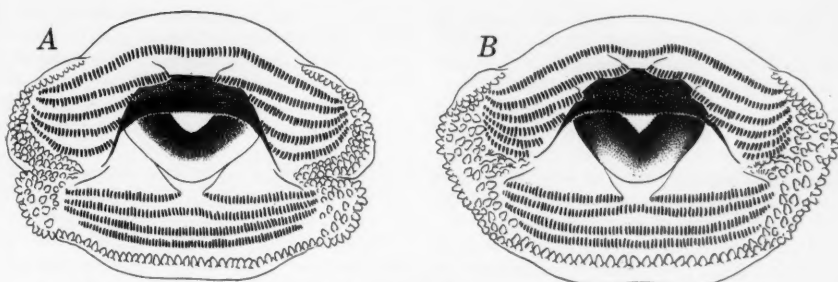


Fig. 4. Mouthparts of larvae of *R. palmipes* from Panama (A) and of *R. macroglossa* from Guatemala (B).

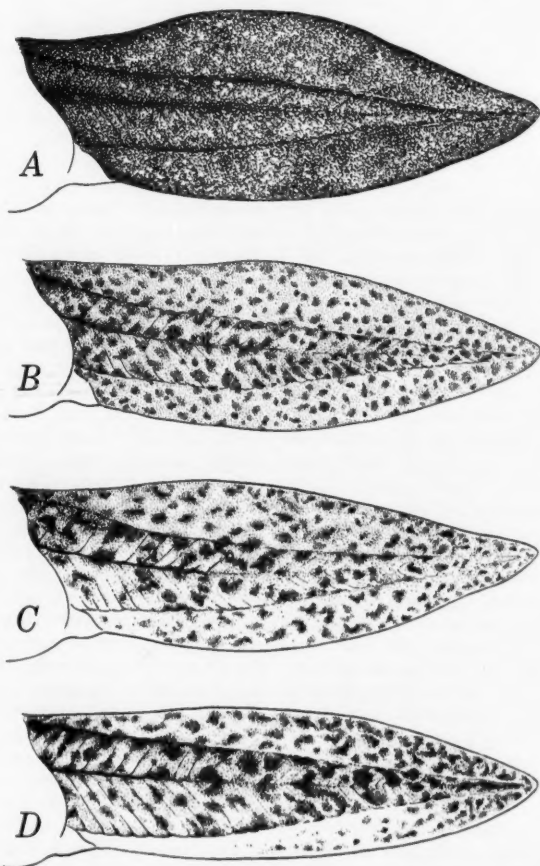


Fig. 5. Shapes and melanophore patterns of tails of larvae of *R. palmipes* from Colombia (A), Panama (B), and Mexico (C), and of *R. macroglossa* from Guatemala (D).

a large complement of teeth, as illustrated in Fig. 4A. In the larva at metamorphic stage XIX (Table II), the fifth upper row has been lost. The mouthparts differ noticeably from those of both the Colombia and Costa Rica larvae in that the median space of the second upper row of teeth is relatively small, varying from 0.20 to 0.50 the length of either lateral segment of teeth (*cf.*, Figs. 2C and 4A).

The  $4/4$  tooth formula of larvae at stage I indicates a precocious development of teeth during the late embryonic period. The only embryos available in the Panama series (AMNH 51772) are in stage 24 (an opercular fold covers the gills on the right side). Teeth are present on the first two upper labial ridges and the first two lower ridges. Embryos of the Costa Rica sample at an equivalent stage of development possess the two lower rows of teeth but only the first upper row. Thus, the eventual higher row count of five in the upper labium of Panama larvae is heralded in the embryonic stages.

The dorsal fin of the tail of the Panama *palmipes* is not as highly arched as that of the Costa Rica larva, and the melanophore pattern is superficially different (*cf.*, Figs. 2C and 5B). The differences in pigmentation patterns are principally quantitative rather than qualitative. Epidermal filamentous melanophores are similarly distributed in the tail, but the "spots" (aggregations of dermal melanophores) in the Panama larvae are smaller in size and more numerous.

GUATEMALA, TRIBUTARY OF UPPER RIO DE LA PASION (= RIO CHAJMAGIC), ABOUT MIDWAY BETWEEN RIO SAN SIMON AND CEIBA, 9 (UMMZ, UNCATALOGUED, COLLECTED BY CARL L. HUBBS AND PARTY, 1935).—All specimens are in the "paddle" stages of larval development, ranging from the absence of interdigital indentations on the distal margin of the hindlimb (stage VI) to the presence of slight indentations between the five toes (stage X). The spotted pattern of the tail, the high arc of the dorsal fin, and the  $4/4$  tooth-row formula in advanced stages of development (Table II) are suggestive of *palmipes* larvae from Costa Rica. There is no indication of the beginning of a fifth upper row of teeth in any of the larvae. A striking anomaly in three of the nine larvae is the continuous first lower row of teeth; a short median space is present in the other five larvae. The tadpoles are best separable from those of *R. macroglossa* from Guatemala on the basis of the tooth-row formula.

Larvae of *macroglossa*, as discussed later, have a  $6/4$  count during identical periods of development. Additional, but less reliable, distinguishing features are the high arc of the dorsal fin and the extensive spotting on the ventral tail fin, not typically found in *macroglossa* larvae.

MEXICO, HACIENDA EL PATIERO, NEAR CORDOBA, VERA CRUZ, 15 (MCZ 24730-32); RIO DE LAS CRUCES AT LAS CRUCES, CHIAPAS, 6 (UMMZ, UNCATALOGUED, COLLECTED BY GORDON AND ATZ, 1939); HEADWATERS OF ARROYO ZACATISPAN, NEAR SAN BARTOLO VILLAGE, 6 MI. S. PAPALOAPAN, OAXACA, 18 (UMMZ, UNCATALOGUED, COLLECTED BY GORDON AND ATZ, 1939); RIO SARABIA AT TRANS-ISTHMUS HIGHWAY  $\pm$  250 FT., OAXACA, 19 (UMMZ, TWO UNCATALOGUED SAMPLES, ONE COLLECTED BY W. E. DUELLMAN, 1956; THE OTHER BY R. R. AND M. MILLER, 1957).—These larvae are referable to *palmipes*. Aggregations of dermal melanophores ("spots") are prominent in the tail musculature and both the dorsal and ventral fins. The melanophore pattern of the tail of a larva from the Oaxaca series is illustrated in Fig. 5C. The epidermal filamentous melanophores are not as densely nor as uniformly distributed as in larvae from Panama and Costa Rica. They are most abundant and compact in the dorsal tail fin. Several regions, particularly those in the anterior portion of the tail musculature and the ventral tail fin are devoid of filamentous melanophores.

The maximum tooth-row formula in the Chiapas, Oaxaca, and Vera Cruz series is  $5/4$  (Table II). All six larvae in the Chiapas sample possess at least a few teeth representing a fifth upper row. This row may be imperfectly developed or absent in advanced tadpoles of the Oaxaca and Vera Cruz series. When present, the fifth upper row generally consists of a few teeth on each side or on one side only.

In the sample from the headwaters of Arroyo Zacatispán in Oaxaca, only four of the 18 specimens possess a fifth upper row. No consistent ontogenetic pattern is evident; a  $5/4$  formula is present in larvae at stages IV, V, and VIII, whereas those in intermediate stages (VI and VII) lack a fifth upper row. The majority of the larvae in the samples from Rio Sarabia in Oaxaca during early development (stages I-III) have a  $4/4$  formula. Larvae with a  $3/4$  formula during this period are apparently retarded in development. Three larvae are missing a fourth lower row, but these were recorded as having a  $4/4$  count. The distorted

condition of the mouth has led us to believe that a fourth lower row was present in life. Moreover, a  $4/3$  formula would be inconsistent with present knowledge of the mode of development of the mouthparts.

In essence, the  $4/4$  formula appears early in ontogeny, as in larvae of the Panama series. However, the fifth upper tooth row in larvae from Mexico, as judged by the samples examined, is not as well-defined nor as consistently present as in larvae from Panama.

#### LARVAE OF *R. macroglossa*

GUATEMALA, 1. MI. N. RABINAL, GUATEMALA, 14 (USNM 123631); APOSENTOS, GUATEMALA, 12 (USNM 123638); RIO LOS ESCALVOS, NEAR PRADO, GUATEMALA, 47 (USNM 123655); TRIBUTARY OF LAKE SAN CRISTOBAL NEAR COBAN, GUATEMALA, 16 (USNM 125335).—The samples comprise an exceptionally fine series of tadpoles collected by R. R. Miller and his colleagues and referred to by Stuart (1951). In his 1951 publication, Stuart considered primarily the ontogenetic changes in the tooth formula. He had earlier (1948, p. 40) presented a detailed description of the tadpole of *macroglossa*, at which time, however, the tadpole was recorded as an unidentified hylid. This misjudgment is comprehensible in terms of the unique configuration of the papillary fringes. The latter are peculiar among ranid species in that the lateral margins are *not* or, at best, slightly emarginate (Fig. 4B). A slight infolding of the lateral papillary border is barely discernible in only a few larvae. In the absence of lateral papillary indentations, the mouth approaches the condition of a sucking disc, characteristic of hylids.

The tooth formula in most advanced larvae is  $6/4$  (Table II). The sixth upper row makes its initial appearance in stage III. No trace of a sixth upper row is evident in five of 81 larvae between stages III and XIX. Two larvae, both in stages XVII, possess a  $7/4$  tooth formula. In the majority of specimens, extra patches of teeth are present in the corners of the mouth, as illustrated in Fig. 4B. A conspicuous feature of the second upper labial row is the narrowness of the median space.

The tooth formula of *macroglossa* larvae from El Salvador, as indicated by Mertens (1952), is  $5/4$ . Since ontogenetic changes were not considered, it can not be ascertained whether this formula is characteristic of most larvae or applicable only to those

in early larval development. In the series of tadpoles from Guatemala examined by Stuart (1951), which include earlier stages of development than those in the samples under consideration, the tooth formula changes from  $2/3$  in 11.25 mm. embryos to  $6/5$  in 62.00 mm. larvae.

The suctorial-like mouth, the high labial count, and the additional patches of teeth suggest that the tadpole is adapted to life in swift waters. The construction of the tail provides further indication of stream adaptation. The dorsal fin is not arched and the tail musculature is extremely well developed. Figure 5 illustrates these striking differences between the streamlined tail of *macroglossa* and the pond-type tails of *palmipes*. The melanophore pattern of the tail is suggestive of *palmipes* from Mexico (cf., Figs. 5C and 5D); a noticeable difference is the sparsity of melanophores in the ventral tail fin of the *macroglossa* larva.

#### CONCLUSIONS AND SUMMARY

*Rana palmipes* from Costa Rica can not be hybridized successfully with the North American *R. clamitans* or *R. pipiens*.

Tadpoles of *palmipes* from Costa Rica, positively identified through comparison with laboratory-reared larvae, resemble to varying degrees those of uncertain parentage but presumed to be of this species from Colombia, Panama, Guatemala, and Mexico. Larvae from each of the latter localities are distinguishable from one another. Whether the variations in the particular samples reflect local population differences, or are characteristic of wider areas to permit the recognition of subspecies, must await the study of populations throughout the range. It may be that the entity currently recognized as *palmipes* is in reality constituted of several different species.

Variations have been noted in the structure of the mouthparts and the melanophore pattern of the tail. The maximum tooth-row formula is  $4/4$  or  $5/4$ . The fifth upper row of teeth is absent from all *palmipes* larvae in the samples examined from Costa Rica and Guatemala. In larvae from other localities, the fifth upper row may be present but is highly variable in expression. It may be well-defined, consisting of a large complement of teeth, as in many advanced larvae from Panama, or imperfectly developed, comprising a few teeth on both sides or one side only, as in most larvae from Mexico.

A prominent feature of the pigmentation

pattern of the tail is the numerous aggregations of dermal dendritic melanophores ("spots") on the tail musculature and both the dorsal and ventral fins. These "spots" vary in size and arrangement in *palmipes* larvae from the various localities examined. Variations occur also in the abundance and distribution of epidermal filamentous melanophores. The latter are most numerous and uniformly distributed in larvae from Colombia and least abundant and irregularly arranged in larvae from Mexico.

The stream-dwelling larvae of *R. macroglossa*, an apparent upland derivative of *palmipes*, possess certain features like those of *palmipes* and others that represent adaptations to swift waters. The suctorial-like mouth, high labial count (6/4), additional irregularly arranged patches of teeth, extensive development of the tail musculature, and reduced tail fins are all indicative of adaptive modifications for a swift water habitat. Indeed, as implied by Stuart (1951), the differences between the larvae of *palmipes* and *macroglossa* are more pronounced than those between the adults. The differences between the adults are stated to be "slight but constant" (Stuart, 1948, p. 41). It remains questionable whether *R. macroglossa* should be considered as a separate species or a highland ecotype (subspecies) of *palmipes*.

Regardless of the eventual taxonomic disposition of the various populations studied, the present investigation emphasizes the need for analyses of larval characteristics throughout the entire developmental period. Descriptions of larvae based on small samples or on single specimens, without consideration of individual, ontogenetic, and geographical variations, are of limited taxonomic value.

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## Water Relationships in *Natrix sipedon*<sup>1</sup>

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GEOGRAPHIC variation in animal populations is presumably a response to varying environmental factors. The use of subspecific designations to adumbrate geographic variation usually relies upon morphological data. The present paper attempts to show how a physiological difference between two contiguous subspecies of the common water snake is related to differences in their respective environments.

The snakes studied are *Natrix sipedon confluens* Blanchard, typically a fresh water race; and *Natrix sipedon clarki* (Baird and Girard), an inhabitant of Gulf Coast salt marshes. Specimens morphologically intermediate between these two subspecies have been recorded from many localities indicating frequent interbreeding. Interbreeding notwithstanding, the two races maintain remarkably distinct morphological characters in areas outside the zone of intergradation. The question arises as to what factors operate to prevent genetic swamping of one or the other of the races.

A promising approach is an investigation of the salinity relationships of the races. These snakes live in or closely associated with the water, and the salinity in their respective habitats is quite different. Extensive collections showed that *clarki* occurs in water containing as much as 73.5 0/00 salt. The maximum salinity recorded where *confluens* was obtained was 4.9 0/00, but the average at such localities was 0.8 0/00.

Previous experiments showed that 30 0/00 salt water (slightly less than that of most oceanic waters) is rapidly fatal to *confluens*. In one series of ten *confluens* placed in test tanks containing water of this salinity, the

maximum survival time was four days with an average of 1.9 days. In a comparable series of *clarki* under the same conditions there were no mortalities even though some individuals were maintained under these conditions for as long as 15 days.

During these experiments specimens of *confluens* suffered a drastic loss of weight immediately prior to death. This decrease is attributed to water loss. Specimens of *clarki* under these conditions show a gradual decrease in weight comparable to that of *confluens* in distilled water. This suggests that snakes of the two races possess different mechanisms for maintaining water balance. The following experiments were conducted in an attempt to identify such differences.

The snakes used in the tests were morphologically typical specimens of their respective races. The examples of *clarki* were collected on Galveston Island. Most of the *confluens* came from Lake Houston, an artificial reservoir in Harris County, Texas. The remaining specimens of this race were taken 1.8 miles west southwest of Highlands, Harris County, Texas.

### SKIN PERMEABILITY TESTS

In seeking an explanation of the mechanism of water balance, it is important to know which organs are involved in water exchange. Bogert and Cowles (1947) studied moisture loss in several species of Floridian reptiles. They assumed that part of the moisture lost by snakes passes through the skin. They state "manifestly a snake can prevent the loss of moisture through the skin by immersing its body or by seeking a moister environment". The loss of moisture in this manner was allegedly more intense at the time of ecdysis. An alternative explanation of a snake's hygrophilic behavior at ecdysis

<sup>1</sup> This study was conducted under the tenure of National Science Foundation Fellowships at the University of Texas and represents a part of a dissertation presented in partial fulfillment of requirements for the degree of Doctor of Philosophy.

seems obvious. That is, moisture will soften the slough and facilitate shedding. The loss of weight at the time of ecdysis, which Bogert and Cowles observed, might well be due to increased metabolic activity that would result in a greater loss of water and carbon dioxide through the lungs.

Skin permeability of the snakes being studied was tested with an osmometer. Two glass cylinders with internal diameters of 15 millimeters were each fitted with ground glass flanges at one end so a membrane could be stretched between them and clamped into place. The opposite end of one cylinder was closed and a capillary tube extended from the opposite end of the other. Solutions could be poured into the two cylinders through ground-glass-stoppered openings on the side of each cylinder. When in operation, the snake skin was placed between the two juxtaposed flanges and clamped into place. A neoprene gasket assured a tight fit. During an experiment both the two glass cylinders and the capillary tube were kept in the horizontal plane. Sea water was placed in the cylinder that had the capillary tube attached and distilled water in the other. The stopper was removed from the cylinder containing distilled water. Both the distilled and sea water were thoroughly aerated prior to use to prevent anaerobia during the time that the cells in the skin remained alive. The skins were placed in the apparatus as soon as possible after removal from the anesthetized snakes. Only skin from the mid-dorsal region was used.

Controls were run on the operation of the apparatus with a parchment paper membrane separating the distilled and sea water. An average of 4.4 ml. per hr. of water was transferred during a 24 hour period while using the artificial membrane.

Skin from three *clarki* and three *confluens* was tested for permeability. In two instances, with samples from each of the two races, the external surface of the skin was in contact with the sea water. No attempt was made to separate the components of the skin and test them individually.

Each experiment was continued for at least 24 hours. According to Davson and Danielli (1943) the permeability of a membrane increases after it dies. The cells in the snake skin undoubtedly died before the experiments were discontinued. Yet, no passage of water through the snake skins was observed at any time during any of the experiments. If a mechanism of active trans-

port was involved, it should have been detected during the early phases of the experiments when the cells were still living. It is concluded that the skins of these snakes are not permeable to water.

#### KIDNEY HISTOLOGY

Since the kidneys of most vertebrates are involved in the maintenance of water balance, a cursory histologic comparison of this organ from the two races was carried out.

Kidney sections from four snakes, two of each race, were prepared in the pathological laboratory of Ernest T. Seton Hospital, Austin, Texas. The tissues were fixed in 1:10 formalin and stained with hemotoxylin and eosin.

No consistent differences in structure of the kidneys were detected between the two races. Well formed renal capsules are present in very small numbers. Some complete transverse sections of this organ showed only one capsule. This contrasts sharply with the greater numbers in mammalian kidneys. The lower metabolic rate of the reptiles is reflected in their limited excretory apparatus.

#### SALINITY DISCRIMINATION EXPERIMENTS

Another series of experiments was conducted in an attempt to determine differences in salinity discrimination and/or preference. The apparatus consisted of a 15 gallon glass aquarium partitioned into two units by a piece of one-half-inch-thick clear plastic cemented midway across the bottom of the tank. The plastic partition was 4¼ inches high. The snakes could easily traverse it in moving from one end of the tank to the other. One gallon of water was maintained in each of the compartments during the tests. The top of the partition was 3¼ inches above the surface of the water. The snakes had only the alternatives of being in fresh water or sea water. The snakes were removed each day, the tank washed, and clean water placed in each compartment. Half the test animals of each race were placed in each compartment upon being returned to the tank. The tank was placed before the center of a window so that the light entering each compartment was equal. A plate glass cover prevented escape of the snakes. The tank was rotated 180 degrees in position daily to equalize any variables such as heat gradients in the ambient air. No temperature controls were possible, nor were variations in water temperature recorded.

The snakes in all the experiments were nearly equal in size. None had been used

previously for any type of test. Prior to the tests they had been maintained for various lengths of time in the laboratory for a minimum of two and one-half months. During this period only tap water had been available to them. All were healthy and none succumbed while being tested. No food was given during the course of the experiments.

Observations were made no sooner than three hours after the snakes had been initially placed in, or returned to, the tank. Succeeding observations were separated by a time interval of at least three hours.

The first discrimination/preference experiment, hereafter referred to as dp-1, involved four *clarki* and four *confluens*. Sea water was placed in one compartment and fresh water in the other. Twenty-five observations were made over an eight day period. The results of this and other discrimination/preference tests are shown in Table I.

Assuming that the snakes make no discriminations, nor have a preference for saline or fresh water, a random distribution would be expected. That is, snakes of either kind would be expected half of the time in sea water and half of the time in fresh water. However, the snakes of both races were observed a greater part of the time in the fresh water compartment. The frequencies of both races in this compartment were identical, 90 out of 100 observations. A chi-square test of the observed frequencies shows that they deviate significantly from the expected ratio ( $P = <0.0001$ ).

The second experiment is referred to as dp-2 in Table I and subsequent discussion. Procedures in this experiment were the same as in the preceding except that fresh water was placed in both compartments. The object of conducting a control experiment of this sort was to determine if only one of the races was actually making salinity discriminations and the other was just "following" it because of some factor such as gregariousness.

Again it is assumed that the snakes will be distributed at random. If this is the case, the expected ratio of each of the two races in the two compartments would be 1:1. Actually *clarki* individuals were observed 45 times in compartment A and 55 times in compartment B. *Confluens* individuals were observed 56 times in compartment A and 44 times in compartment B. Chi-square tests of the observed frequencies show that in neither case do these frequencies deviate significantly from a random distribution. The probabilities of such distributions are greater

than 0.45 and 0.35 for *clarki* and *confluens* respectively.

The data obtained from the preceding experiment (dp-2) also provide information on the psychological reactions of individuals of the two races to each other. Since both compartments contained fresh water, there were no physical factors impelling the two forms to remain in either one or the other

TABLE I  
OBSERVED FREQUENCIES IN SALINITY  
DISCRIMINATION/PREFERENCE TESTS OF  
*N. s. confluens* AND *N. s. clarki*

	<i>confluens</i> In Sea Water	<i>confluens</i> In Fresh Water	<i>clarki</i> In Sea Water	<i>clarki</i> In Fresh Water
dp-1	10	90	10	90
dp-3	14	86	—	—
dp-4	—	—	8	92
	<i>confluens</i> In Chamber A	<i>confluens</i> In Chamber B	<i>clarki</i> In Chamber A	<i>clarki</i> In Chamber B
dp-2	56	44	45	55

TABLE II  
ASSOCIATION FREQUENCIES OF *N. s.*  
*confluens* AND *N. s. clarki* IN  
TEST TANK\*

	<i>N. s. clarki</i> 66				
	4 in A	3 in A	2 in A	1 in A	4 in B
4 in A	2	3	2	1	—
3 in A	2	2	—	2	—
2 in A	—	—	1	1	—
1 in A	—	—	1	—	1
4 in B	—	—	1	1	5

\* In the headings, the first figure in combination refers to the number of snakes and the letters to the compartments.

of the two compartments; hence assortative associations could be formed.

On the assumption that the snakes will make no discrimination between members of their own race and those of the other race, no assortative association preferences could exist and a random distribution (1:1 ratio) of each of the two races in the two compartments would be expected. When the observed distributional frequencies are submitted to a chi-square test the foregoing assumption is supported ( $P = >0.5$ ). The association frequencies of this experiment given in Table

II show clearly that the snakes tend to aggregate without regard to racial identity.

A reciprocal of the preceding experiment, using sea water in both compartments, would have been desirable, but was impossible because *confluens* cannot tolerate such conditions.

In the third experiment (dp-3), four *confluens* were placed in the test tank. The object was to determine the reactions of *confluens* in the absence of *clarki*. Since experiment dp-2 had shown that the snakes did tend to be gregarious, it was necessary to determine whether the distribution of *confluens* in experiment dp-1 was based upon choices made by the *confluens* themselves, or whether they were remaining in the fresh water compartment because *clarki* was there most of the time.

On the assumption that *confluens* neither makes no discrimination between, nor has any preference for salt or fresh water, then the expected ratio for the snakes observed in the two compartments would be 1:1. They were observed 86 times in the fresh water compartment as compared to 14 times in the sea water compartment. A chi-squared test of these frequencies strongly indicates the foregoing assumption to be false ( $P = <0.0001$ ). Apparently *confluens* can make the necessary discrimination and prefers fresh water.

The fourth discrimination/preference experiment was identical with the one preceding except that four *clarki* were used instead of *confluens*. The purpose of this test was to determine how *clarki* would react in choice of water if *confluens* were absent. The snakes were observed 92 times in fresh water and eight times in sea water during this experiment. When these frequencies were subjected to a chi-square test, the assumption of random distribution of the snakes was proved false ( $P = <0.0001$ ).

In summary, it appears that snakes of both races are capable of discriminating between sea water and fresh water and that they prefer the latter.

#### DISCUSSION

To identify the mechanisms of water balance in these snakes, data from several experiments must be considered. First, previous experiments had shown *confluens* to be unable to withstand prolonged periods of partial immersion in sea water. Such treatment always results in a rapid decrease in weight followed by death. Under the same condition *clarki* loses weight slowly and shows no signs

of being adversely affected. If this weight loss may be interpreted as water loss, it then becomes apparent that *confluens* is unable to maintain water balance in sea water and death ensues.

The mechanism of salinity tolerance in *clarki* is indicated by these experiments. Comparison of weight curves of *clarki* and *confluens* show that in almost every case individual *confluens* both gained and lost weight while on test, but the weight of *clarki* never increased. This is interpreted as meaning *confluens* drank the sea water into which they were placed, but the *clarki* did not.

The skin permeability tests suggest very strongly that any water that entered the body of the animals did so by way of the digestive tract. Once a sufficient quantity of the sea water is in the digestive tract, water from the tissues of the snake, obeying an osmotic gradient, begins to pass through the intestinal wall into the lumen. Necropsies of snakes killed by sea water revealed that their intestines were distended with water, thus attesting the existence of the proposed mechanism of water loss.

If extrapolations from marine mammals may be applied to *clarki* there is evidence that this snake can maintain its water balance in nature by utilizing preformed water from the body of its prey and metabolic water produced by the oxidation of food materials. The low concentration of salts in the blood of teleost fishes is well known. Under natural conditions *clarki* probably feeds exclusively upon these fish and from them obtains much of the water required. Smith (1936), Irving, *et al.* (1935), Fetcher and Fetcher (1942) and others have studied this problem in seals and cetaceans and are generally in agreement that these animals maintain their water balance in the same manner as outlined above for *clarki*. Obtaining sufficient water would be less of a problem for the snakes than for the mammals, because the snakes do not have the problems of excreting a liquid urine and of lactation that confront the mammals.

The salinity discrimination/preference tests with *confluens* show that this snake can distinguish between sea water and fresh water, but this cannot be construed as evidence that *confluens* would not drink sea water if only this liquid was available. Specimens of *clarki* were observed drinking large quantities of fresh water on six occasions after experiments upon them in sea water were discon-

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tinued. These snakes had not been fed during the course of the experiments and were presumably dehydrated. If they regularly drank sea water in quantity there was no good reason for them to have been thirsty at this time, because they had been partially immersed in it while on test.

It may be concluded that differences in the behavior of these snakes lead to the differences observed in their salinity tolerance.

#### SUMMARY

Water relationships in two subspecies of the common water snake, *N. s. confluent* and *N. s. clarki*, were investigated. Since previous experiments had indicated differences in the mechanisms by which these two snakes maintained water balance, a further series of tests was conducted in an attempt to identify these differences.

Permeability of the skin of these two races was tested with an osmometer. No water transfer through this organ could be demonstrated in either subspecies. It is concluded that the skin performs no role in water transfer.

Differences in kidney structure were sought in a cursory histological investigation. No differences were observed. However, it is suggested that refinement of technique and more detailed study might show such a conclusion to be premature.

A series of salinity discrimination and preference experiments showed that individuals of both subspecies preferred fresh water to sea water when they had only the alternatives of being partially immersed in one or the other.

It is concluded that *clarki* can maintain water balance through the utilization of preformed water from the body of its prey plus water derived from oxidative metabolism. Moreover, *clarki* will not drink water of 30 0/00 salinity, whereas *confluens* will drink it and subsequently succumb to its effects. Because of this behavior trait *confluens*, a fresh water race, cannot occupy the salt marsh habitat where *clarki* regularly occurs.

#### ACKNOWLEDGMENTS

The author is pleased to acknowledge the advice and guidance of Dr. W. Frank Blair of The University of Texas. Dr. O. Willford Olsen and Dr. Richard S. Miller of Colorado State University have read the manuscript. Their comments and criticisms are appreciated.

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## The Photic Responses and Water-approach Behavior of Hatchling Turtles<sup>1</sup>

PAUL K. ANDERSON

**P**UBLISHED material on the water-approach behavior of neo-nate turtles is pertinent to two environmental situations. The sea-approach behavior of the Loggerhead, *Caretta caretta*, on ocean beaches was studied by Hooker (1911), Parker (1922), and

Daniel and Smith (1947, 1947a). The water-approach behavior of hatchlings of three fresh water species (*Cheelydra serpentina*, *Sternotherus odoratus* and *Chrysemys picta*) which nest in dense vegetation was investigated by Noble and Breslau (1939).

In the summer of 1955 the author studied turtle populations of the Pearl River in

<sup>1</sup> Research conducted at Department of Zoology, Tulane University. Present address: Museum of Vertebrate Zoology, University of California.

Louisiana and Mississippi. Three turtles, *Trionyx muticus*, *Graptemys pulchra*, and *Graptemys oculifera*, nest on sandbars along the Pearl. The conditions under which turtle hatchlings from these nests move to the water approximate those of ocean beaches except that there is no surf. The nests of the *Graptemys* are located at the landward margin; those of *Trionyx* are out on the open sandbar (Fig. 1, (A) and (B)). The water may or may not be visible from the nest site. Hatch-

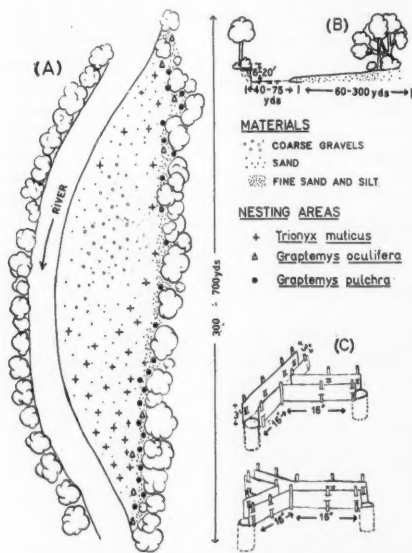


Fig. 1. (A) Typical Pearl River sandbar showing distribution of nests of three species of turtles in relation to vegetation and sedimentation pattern. (B) Cross-sectional representation of sandbar. (C) Construction of "T" and "Y" mazes used in investigations. No. 2 cans sunk in sand are represented by dotted lines.

lings leave these nests within the first three hours after sunset, the one time in their lives when they are nocturnally active, and make their way to the water by a direct route.

#### METHODS

Hatchlings used in experiments were obtained from eggs incubated in a metal and screen box buried on a sandbar, or were taken in traps that intercepted them on their way to the water. For study of orientation behavior mazes of transparent plastic material (Sears & Roebuck "Sunray") were constructed on the sandbars (Fig. 1, (C)). At the gates of

the mazes No. 2 cans were sunk in the sand, serving as traps and thus permitting the observer to leave the animals undisturbed while they ran the maze. Animals were handled with a minimum of disturbance and were allowed to accommodate to existing light conditions before being tested. New individuals were substituted after 1 to 4 trials to minimize the possibility of maze learning. Animals were released in the stem of the maze facing the choice point. All experiments took place on the sandbars and, unless otherwise stated, were carried on at night.

#### PRELIMINARY INVESTIGATIONS

Response to artificial light at night showed individual variation. Three *Trionyx* were released on the sand 20 feet from a group of trees on the forest side and 100 yards from the water. After raising their heads and looking about briefly, they oriented themselves and moved in the direction of the water although it was not visible. A flashlight was laid on the sand with its beam shining across and at right angles to the path of the turtles. One individual showed a positive phototaxis in repeated trials, stopping, turning and following the beam until halted by the flashlight lens. The second individual showed a similar reaction in stopping in the light beam, but would continue on towards the water. The third individual seemed to be uninfluenced by the light. Each individual showed these reactions in three or four trials.

Similar variation in phototropic reaction was observed when a kerosene lamp was placed between hatchlings and the water. This lamp had a base such that the flame was approximately ten inches above the ground. When several turtles were simultaneously released 15 feet from the lamp on the landward side all proceeded toward the water. Some went past the lamp and on toward the water without deviation. Others approached the base of the lamp, passed it, and then began to circle the light. Of these individuals some reoriented themselves and continued toward the water after one circle, others circled the light at a distance of 6 to 10 feet until retrieved.

Further tests of phototropic reaction were made in a "Y" maze utilizing a flashlight or the light of the moon as a stimulus. The results (Fig. 2) indicate that a positive response to light may generally be obtained.

#### DIURNAL RESPONSE

Contrasting behavior was exhibited during the day. *Trionyx muticus* hatchlings retained

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in five-gallon cans filled with sand were active on the surface at night, but burrowed beneath the sand during the daytime. If released in bright sunlight, even within two feet of the water, they would burrow rather than move in any direction. Hatchling *Graptemys* also showed negative reactions to bright sunlight. Individuals placed on the sand within two feet of the water turned and moved to the nearest shade or to the forest some distance away.

The relationship of the negative and positive reactions was investigated by means of maze experiments during the period of sunset. The experiments were initiated during full daylight at 5 PM and continued until after full darkness at 8 PM. Readings of light intensity in the sky directly overhead were taken with a Weston Master II photoelectric meter. The orientation of the mazes and the results obtained are shown in Fig. 3. The shift in behavior with decreasing light intensity is clearly indicated.

#### WATER-APPROACH BEHAVIOR

The undisturbed behavior of *Trionyx* hatchlings in moving from nests to the water may be studied by observation of trails left in the sand. At the nest site a conical depression, 2 to 3 inches wide and 1 inch deep, marks the point of emergence of the young turtles. Since all individuals emerge within two hours of each other, light conditions, temperature, and landmarks vary only slightly and while the hatchling trails typically radiate somewhat from the nest they follow the same broad pattern, characteristic of the particular location.

In an effort to increase the efficiency of traps used in obtaining hatchlings the oil lamp used in the preliminary investigations was placed on the sandbar and left burning during the night. *Trionyx* hatchlings emerged from a nest on the landward side of this lamp and proceeded past it toward the water. Their reaction to the light as indicated by their trails showed no evidence of phototropism. An unusual confusion was indicated, however, suggesting that while the light failed to attract the hatchlings it masked some important cue or cues normally utilized. This pattern of trails suggested that the hatchlings might react in some way to the mass of shadow, or to the skyline, formed by the forest. A test of this hypothesis was made by setting up a "T" maze and running a series of control tests which showed a clear orientation toward the water 150 feet away (Fig. 4, A)). A tarpaulin was then hung on poles

three feet from the maze gate leading toward the water. This tarpaulin formed a dark mass on the skyline relatively higher and closer

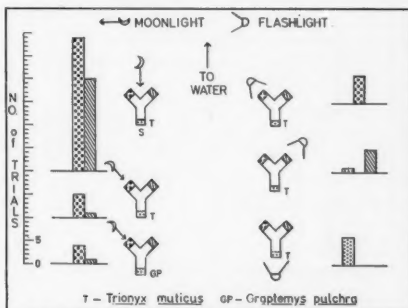


Fig. 2. Response of hatchlings to artificial and natural light. Turtles were placed in the maze near the "S" gate (upper left figure) facing the fork. Light sources are indicated by symbols (moon and flashlight). Individuals choosing each gate indicated in accompanying histograms.

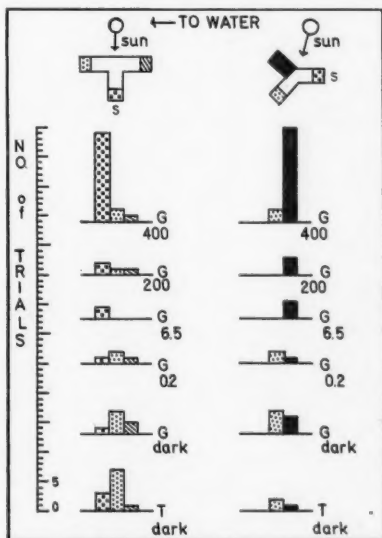


Fig. 3. Transition between diurnal and nocturnal response by *Graptemys* (G) and *Trionyx* (T) hatchlings. The black arm of the "Y" maze was shaded with strips of cardboard. Response in each maze indicated in the subtending histograms. Figures represent light intensity in foot candles as measured with Weston Master II meter.

than that of the forest on the landward side. The orientation of the turtles was reversed (Fig. 4, B).

In a further test the maze was placed on the landward side of a clump of willow trees located on the edge of the water and sepa-

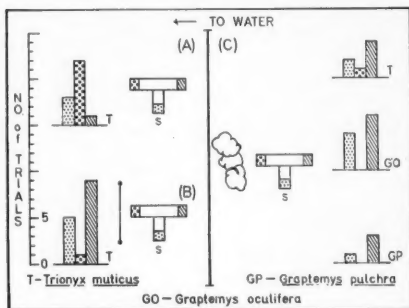


Fig. 4. Response to masses of dark shadow. The orientation towards the water shown in (A) was reversed when a tarpaulin (3 feet high, 6 feet wide) was erected, as in (B). In (C) the maze was placed behind a waterside clump of willows and hatchlings chose gates leading away from the water.

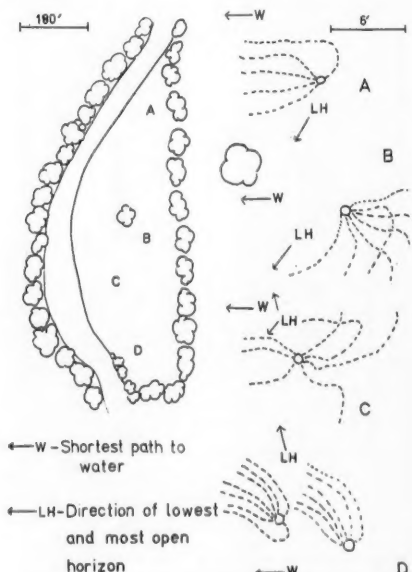


Fig. 5. Trails of neo-nate turtles in different situations on a sandbar. The pattern found in each location is indicated in an enlarged diagram associated with the same letter. Shortest route to the water is indicated by "W," direction of the lowest horizon by "LH."

rated by open sand from the forest margin 50 yards away. The orientation of the turtles was away from the willows and thus away from the water (Fig. 4, C).

These results were supported and clarified by examination of more than 25 sets of trails left by hatchlings on their way to the water. Four situations in regard to nest location are illustrated in Fig. 5. In the first (A) the nest was located so that the landward forest was closer than that on the opposite bank of the river. Here the trails showed quick and consistent orientation. In the second (B) a tree was located nearly on the line from the nest to the water. The trails showed a preliminary orientation away from the tree and a subsequent reorientation. In the third (C) the nest was so located that it lay midway between the two forest margins. The trails showed no general orientation and wandering on the part of most individuals until a proper orientation was achieved. In the fourth situation (D) the nest was located at the end of a sandbar where it was surrounded by vegetation on three sides. There was a primary orientation away from this vegetation and a gradual swing toward the water.

#### DISCUSSION

Hatchling orientation has been explained in the literature as due to positive response to light. In reference to *Caretta*, Hooker (1911) concluded that the movement was a positive reaction to light reflected from the water. Parker (1922) felt that his results indicated a more complex behavior than could be attributed to an unmodified phototaxis and concluded that the turtles moved away from an interrupted horizon toward the most open and regular horizon in view. Both authors studied the orientation of the animals in daylight. Daniel and Smith (1947, 1947a) noted that the nests always had a direct line of sight to the water and that the seaward movement usually took place at night. They concluded that the movement was the result of photokinetic and phototactic reactions to the bright surf of ocean beaches and reported that orientation broke down on a moonless, surflless night. Further, since the turtles approached a brighter but broken pattern in contrast to a less intense but uniform field of light they thought it "unlikely that the presence or absence of trees, shrubs, or sand dunes defines the seaward movements."

Noble and Breslau (1939), studying hatchlings which must approach the water through dense vegetation, concluded that orientation was a response to large areas of illumination and supported their laboratory findings by an observation of a diurnal movement of

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hatchling *Chelydra* which they interpreted as a response to the most open horizon.

While positive response to light was demonstrated in the present study, its direct relationship to water-approach behavior is made doubtful by the great degree of individual variation and by failure of the trails of animals emerging from an undisturbed nest to reflect any positive response to the oil lamp. In terms of light the basic environmental elements are the relatively bright sky and sand and the dark water and vegetation. Since the majority of the animals are on the sand when they emerge from the nest the light sand may be eliminated except for possible importance where *Graptemys* nests are located just inside the margin of vegetation behind the sandbar. Effective orientation when the water cannot be seen, as well as occasional confusion when it can (patterns such as Fig. 5, C), suggest that light reflected from the water is not involved. Unlike *Caretta* the Pearl River turtles orient successfully in the absence of moonlight and of surf.

Two methods of orientation by reference to the sky have been suggested in the literature; a positive response to the lowest and least interrupted extension of the light sky on the horizon (Parker), and a response to the maximum area of open sky (Noble and Breslau). In the present environment the direction of the lowest horizon and that of the maximum visible sky is not toward the water but toward the center of the sandbar (Fig. 1, A and B). Under this hypothesis we should expect turtles in situations such as Fig. 5, A and D, to move along the lengthwise axis of the bar.

It has been indicated earlier that the dark mass of shadow formed by the forest might affect orientation. As is indicated in Fig. 5 the trails of turtles leaving a particular nest were often grouped about a common axis away from the nearest mass of vegetation. Postulation of orientation through negative response to dark masses is compatible with all observed trail patterns and with the re-

sults obtained in the maze experiments. Such a primary orientation, possibly reinforced in the later stages by a tendency to telotaxis (suggested by Daniel and Smith) or by some direct visual response to the water, would satisfactorily explain the behavior of *Trionyx* and *Graptemys* hatchlings on the Pearl River sandbars. The general literature of orientation behavior, however, offers no instance of such a negative orientation to dark objects. In view of this the explanation outlined here must await further critical experiments before it may be fully accepted. It is apparent that many variations in orientation mechanism exist in turtles and that further study of this behavior is needed.

#### ACKNOWLEDGMENTS

The author is grateful to Paul Marhenke of Berkeley, California, who served as research assistant in this work. He is grateful also to Dr. Fred R. Cagle of Tulane University, Dr. Donald Tinkle of Texas Technological College, and Drs. Robert C. Stebbins and Peter Marler of the University of California for critical reading of the manuscript. A loan from the Revolving Research Fund of ASIH supported the broader studies to which these observations were incident.

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## Herpetological Notes

BODY MEASUREMENTS OF *SCAPHIOPUS HOLBROOKI*.—Formulae were given (Pearson, 1955, *Ecol. Monogr.*, 25: 255) that expressed the relationships between greatest head width, body length, and interorbital distance for a random

sample of 112 spadefoot toads taken near Gainesville, Florida during October, 1951. One of the reasons for giving the three equations was for the purpose of calculating any two of these body measurements when the third was known. I

thank Frederick B. Turner and L. M. Klauber for calling my attention to errors and inconsistencies in these formulae. The original data have been reexamined (four specimens were eliminated due to obvious measurement errors) and the various relationships between head width (Y), body length (X), and interorbital distance (Z) are given in Table 1.

One purpose of this paper is to indicate that the three equations published earlier could only have been used to estimate Y when either X or Z was known, or to estimate Z when X was known. This is true since, for example, the equation  $Y = 2.75 + .288X$  (derived by the method of least squares) provides a line that minimizes the deviation between it and the observed Y values for any particular value of X. Thus, this provides the best estimate of the average Y for

sample to individuals from a different kind of sample.

To pursue this problem, data on head width and body length measurements from four types of samples were studied. The randomly selected population mentioned above was used (Table 1) and its approximate size group distribution can be judged from Tables 17 and 18 (Pearson, *op. cit.*). The variance of the slope ( $S_b^2$ ) was calculated by the methods given in Snedecor (*op. cit.*, p. 122). Two age and sex specific samples were studied when data cards on 20 adult males and 20 adult females were chosen randomly from a large sample of toads trapped August 25, 1953, during breeding migrations. These toads represented a population that had far higher frequencies of older, larger toads than the 1951 population (Pearson, *op. cit.*). Data on

TABLE 1

RELATIONSHIPS OF BODY MEASUREMENTS IN FOUR TYPES OF SAMPLES FROM THE SAME POPULATION  
Total body length = X, head width = Y, interorbital distance = Z.

Sample Type	N	Mean (Range)	Rectilinear Equation	Slope Variance
Random Sample, October, 1951	108	Y: 16.8(12-21.0) X: 48.7(34-67) Z: 5.4(3.4-6.9)	$Y = 2.75 + 0.288X$ $X = -3.99 + 3.14Y$ $Z = 0.43 + 0.296Y$ $Y = 3.6 + 2.44Z$ $Z = 0.96 + 0.091X$ $X = 4.37 + 8.21Z$	.00008 .0095 .0003 .0215 .00003 .2131
Adult Males	20	Y: 18.6(17.1-20.3) X: 57.7(51-64)	$Y = 4.51 + 0.244X$ $X = -7.21 + 3.49Y$	.0004 .118
Adult Females	20	Y: 17.5(15.6-19.6) X: 53.4(46-60)	$Y = 3.34 + 0.266X$ $X = 3.24 + 2.86Y$	.0006 .141
Young	8	Y: 10.2(8.3-12.2) X: 30.3(26-35)	$Y = -.56 + 0.355X$ $X = 3.78 + 2.60Y$	.0012 .096

any known X. If we know the head width (Y) and wished to estimate body length (X) the equation  $X = -3.99 + 3.14Y$  would be used and in this case the derived line would minimize the deviation of observed X values from it at any value of Y. In addition, it is emphasized that this equation only estimates the average X value for any head width and we expect a much larger range of observed deviations from this average near the extreme Y values than near the mean of Y. The probable deviation from the estimated values can be calculated according to the methods of Snedecor (*Statistical Methods*, 1946, p. 117-20).

Since the head width and body length relationships are probably of greater interest, a second purpose of this paper is to determine whether the relationships of these two body measurements differ between the sexes or between the very young and the old toads. If the relationships do differ one needs to be careful about the application of equations derived from one

these two samples are given in Table 1. The fourth type of sample included measurements of six young toads that resulted from a breeding chorus on April 7, 1953, and were collected in August 1953.

The difference between the slopes (b) of these four samples was tested using the null hypothesis in a *t* test where:

$$t = \frac{b_1 - b_2}{\sqrt{S_{b_1}^2 + S_{b_2}^2}}$$

Tests for significance of difference between slopes were first made on the  $Y = a + bX$  equations. These tests showed that there are significant differences between the regression slopes of the sample of young and (1) the adult males ( $t = 3.2$ ,  $P = .01$ ), and (2) the adult females ( $t = 2.1$ ,  $P = .05$ ). The random sample had a slope significantly different from that of the adult males ( $t = 2.01$ ,  $P = .05$ ). These results are interpreted to mean that for these samples there was a

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significantly different relationship between the young and older toads; the difference between the random sample and the adult male sample being due to the influence of the young toads in the random sample. There was no difference in this type of relationship between adult males and females.

When this type of analysis of regression coefficients of the four samples was made on the  $X = Ax + bY$  equations there was no evidence that they could be considered statistically different at the 5 percent probability level. Significant differences were not illustrated between samples in the estimation of body length since there was such a considerable variation of body length within each of the samples for any given head width as a result of measurement error. This made a larger variance than that of head width and thus probably accounts for the difference in the results on the two types of equations.

In summary, the head width and body length are correlated and one can be estimated from the other. There are two different equations derived by the method of least squares to be used depending on which measurement is known and

which is to be estimated. Secondly, one should be cautious in the application of statistics derived from one sample to individuals derived from a second sample unless there is reason to believe that the samples are relatively homogeneous in nature and the linear relationships do not differ between the samples. PAUL G. PEARSON, *Rutgers, The State University, New Brunswick, New Jersey.*

**THE WATER ABSORPTION RESPONSE OF AN ANURAN.**—Stille, (1952, *Ecology* 35: 155-6) noted that the toad, *Bufo woodhousei fowleri* Hinckley, assumed a characteristic position prior to absorbing water from a wet surface or substrate. In this position the tarsus was not under the knee. The tarsus and foot are usually directly under the knee when a toad is on a dry surface or not absorbing water. Further, pulsations due to the action of the posterior lymph hearts seem to continue during water absorption. This behavior, called the water absorption response, seems to be widespread among Anurans.

Observations have been made on individuals of *Acris g. crepitans*, *Hyla crucifer*, *H. versicolor*,

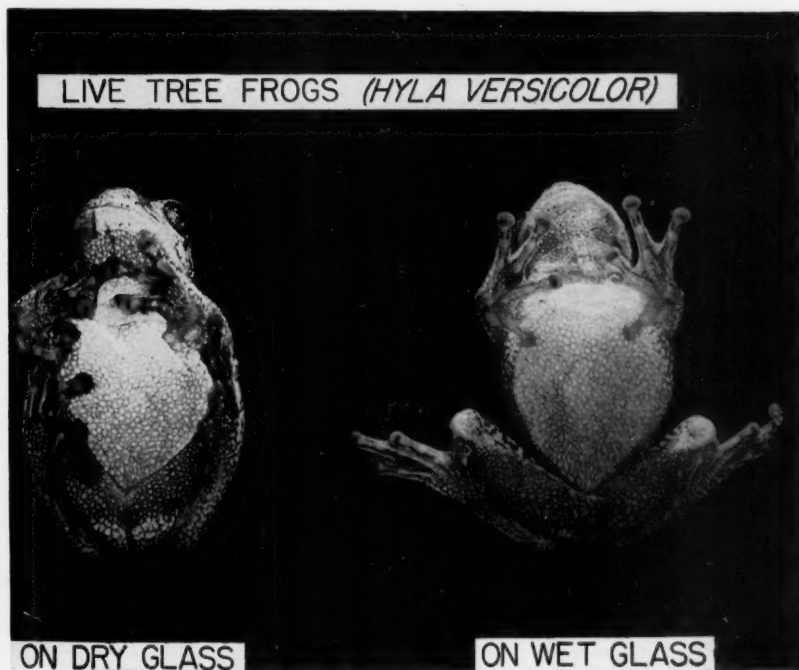


Fig. 1. The water absorption response. The anuran resting position, shown in the ventral view of the frog on dry glass, is modified to that of the specimen on wet glass when active absorption of water is begun.

*Pseudacris n. triseriata*, *Bufo t. americanus*, *B. w. fowleri*, *Rana clamitans*, *R. pipiens* and *R. sylvatica* collected near Chicago. Each individual was exposed to evaporation in room atmosphere until it lost about 10 to 20 percent of its initial weight. Each individual was then permitted to become quiescent on a wet substrate. In every case (and in all subsequent retestings) the normal sitting position was modified and the water absorption response was elicited (Fig. 1).

Anurans absorbing water from a wet permeable substrate (e.g. sand, cloth, sponge) usually remain motionless. With substrates only slightly moist (and therefore with greatly reduced permeability), water absorption continues for as long as several days.

Anurans absorbing water from rather impermeable surfaces (e.g. glass, stone, plant leaves) continually shift position. This wiping behavior was noted in all frogs studied. Tree frogs tested on dew-covered white oak leaves climbed onto a leaf and adopted the water absorption position. Then, by a series of wiping motions the frog removed much of the dew on the leaf. The weight of the frog usually caused the leaf to partially overlay a lower leaf. Hence, the frogs were able to descend from leaf to leaf without an obvious change in wiping movements. Each abandoned leaf returned to its former position as the frog left it for another leaf. Only the Dunes toad, *B. w. fowleri*, has been observed absorbing water from a wet substrate (and without entering water) under natural conditions.—W. T. STILLE, *Saunders Road, Lake Forest, Illinois*.

**A COLLECTION OF AMPHIBIANS AND REPTILES FROM JAPAN.**—A collection of 66 specimens of amphibians and reptiles representing 13 species was made by the senior author on the islands of Honshu (Hondo) and Shikoku from September 1954 through August 1956. Two specimens of one form were purchased in Yokohama. All specimens are deposited in the collection of the University of Oklahoma Museum of Zoology (UOMZ).

*Triturus pyrrhogaster* (Boie).—(3, UOMZ 27519–21). Three specimens were taken near a small spring fed pool near Niihama, Shikoku on August 13, 1956. The snout-vent measurements of the living animals are 44 mm. to 50 mm., the average is 46.6 mm.

*Bufo vulgaris japonicus* Schlegel. —(9, UOMZ 27492–8, 27517–8). The vicinity of Yokohama, Kanagawa Prefecture, Honshu. This common toad, collected mostly during the months of April, May and June, was found quite often in burrows or shallow depressions in soft earth in

the midst of thick vegetation or it was found active at night. One individual, (UOMZ 27492) was found in a semi dormant state on February 14, 1956 sunning in its burrow; the air temperature was 63°F.

*Bufo* eggs were found in a fish pond on April 15, 1956.

UOMZ 27493 (head and fore limbs only) was recovered from the stomach of a *Natrix tigrina tigrina* (UOMZ 28984) captured on June 10, 1956.

*Hyla arborea japonica* Günther. —(9, UOMZ 27485–91, 27675–6). UOMZ 27675–6 are from Niihama, Shikoku; the remainder were taken at Ofuna, Yokohama and Yokosuka, Kanagawa Prefecture, Honshu. This frog, found in diverse habitats from April through October, was common in small trees (at heights averaging 3 feet above the ground), along margins of rice paddies, in brush piles and in roadside ditches. The snout-vent measurements of the living animals are 21 mm. to 36 mm., the average is 24 mm.

*Rana japonica* (Günther). —(18, UOMZ 27524–41). These frogs were taken in the vicinity of Yokohama, Kanagawa Prefecture, Honshu. They were found only about the margins of paddies from May through October. The paddies were often bordered by tall grasses. One specimen (UOMZ 27524) had a grasshopper in its mouth. The snout-vent measurements of the living animals are 17 mm. to 57 mm., the average is 45.3 mm.

*Rana nigromaculata nigromaculata* Hallowell. —(1, UOMZ 27542). This specimen, taken near Yokohama, Kanagawa Prefecture, Honshu, on June 10, 1956, was found near the edge of a paddy.

*Rhacophorus schlegelii schlegelii* (Günther). —(1, UOMZ 27484). This specimen, taken in Yokohama, Kanagawa Prefecture, Honshu, on July 28, 1956 was found on a leaf in a shady area of a hilly wooded region. The snout-vent measurement of the live specimen is 55 mm.

*Eumeces latiscutatus latiscutatus* (Hallowell). —(4, UOMZ 28971–4). This skink was found in Ofuna and Numazu, Kanagawa Prefecture, Honshu, on May 5, 1955 sunning on bare areas on the ground or on rock piles.

*Takydromus tachydromoides* (Schlegel). —(7, UOMZ 28985–91). This lizard was collected in Hakone-machi, Yokohama and Ofuna, Kanagawa Prefecture, Honshu during the months of April, May and June of 1955, and June of 1956. It was usually observed sunning in areas of bare ground or on rock piles, but could sometimes be found in high grasses. The body lengths of the living specimens are 38 mm. to 57 mm., the average is 45.5 mm.

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*Elaphe climacophora* (Boie).—(3, UOMZ 28970, 28976–7). During October 1955 and April 1956 three specimens were taken in the Honmoku-machi section of Yokohama, Kanagawa Prefecture, Honshu. These came from partially wooded hilly areas. One specimen, shaken from a tree, fell about 25 feet; whereupon its behavior resembled that of *Elaphe obsoleta*, hissing and striking with mouth agape. The snake closed its mouth before actual contact, resuming the defensive position without biting. Another individual was captured within 4 feet of a crevice in the same tree in April 1956. The crevice was partially filled with decaying debris, and may have served as a hibernaculum for the snake through the winter.

The body lengths of the living snakes are 346 mm. to 1220 mm., the average is 886 mm. The specimens are all females.

*Elaphe conspicillata* (Boie).—(1, UOMZ 28978). This snake was taken on June 13, 1955 near Hakone-machi, Kanagawa Prefecture, Honshu. The snake was sunning on a rock wall about 14 inches above the ground near the edge of Lake Hakone. The lake is situated in the midst of a hilly, heavily wooded region. A female, the body length of the living specimen is 677 mm.

*Elaphe quadrivirgata* (Boie).—(2, UOMZ 28975, 28992). UOMZ 28975 was taken in the Honmoku-machi section of Yokohama, Kanagawa Prefecture, Honshu on April 23, 1956; and 28992 was captured near Niihama, Shikoku on August 13, 1956. The first specimen was found sunning on a rock pile, fleeing into tall grass where it was captured. The second snake, a melanistic phase, was taken near a water seepage from a hillside. The body length of the first individual, a male, was 522 mm. while living.

*Natrix tigrina tigrina* (Boie).—(6, UOMZ 28979–84). This snake was taken during the months of June, September and October in Ofuna and Yokohama, Kanagawa Prefecture, Honshu. This species seems to prefer heavily wooded regions close to paddies for a source of food, probably *Rana* and *Bufo*. UOMZ 28984 yielded the remains (head and forelimbs) of a *Bufo vulgaris japonicus* which was taken tail first. The body lengths of three live males are 432 mm. to 622 mm., the average is 533 mm.; for three females, 571 mm. to 767 mm., the average is 697 mm.

*Agkistrodon blomhoffi blomhoffi* (Boie).—(2, UOMZ 29069–70). These snakes, known locally as "Mamushi," were purchased in Yokohama, Kanagawa Prefecture, Honshu on December 15, 1955.—DONALD R. ALEXANDER AND RICHARD A.

DIENER, Department of Zoology, University of Oklahoma, Norman, Oklahoma.

THE WINTER ACTIVITIES OF *RANA CLAMITANS* TADPOLES.—The only reference concerning the winter activities of *Rana clamitans* tadpoles in the northern part of their range is that of Morgan (1939, Fieldbook of Animals in Winter, pp. 358–9). She stated that they usually burrow 4 to 6 inches in the mud and hibernate during the cold months.

Tadpoles of this frog were observed actively swimming in the open water throughout the cold months in shallow, permanent ponds on Fort Devens Military Reservation in Massachusetts during the winter of 1954–55. The ponds had a depth of approximately 3 feet and the sandy bottoms supported an abundant growth of rooted aquatic vegetation. Water temperatures were not taken at any time, but collections made January 9 and 16, 1955 were taken from under 6 inches of ice.

Although the stomachs and intestines contained food, this does not prove that feeding took place during the winter. Digestive processes are undoubtedly slowed down at low temperatures and it is possible that the alimentary contents were food taken during warmer months. It seems quite probable, however, that they were feeding and digesting the food since they were active all winter. Noble (1931, The Biology of the Amphibia, pp. 209–10) stated that some tadpoles are able to withstand long fasts by living on their own tissues.

On November 29, 1957 Dr. Henry van der Schalie (personal communication) collected *R. clamitans* tadpoles from a shallow backwater of the Huron River near Ann Arbor, Michigan. These individuals were also apparently active even though ice was forming on the surface at the time. The water depth was about 3 feet. The bottom was composed mainly of mud and supported a rather dense growth of aquatic vegetation.—LOWELL L. GETZ, Department of Zoology, University of Michigan, Ann Arbor, Michigan.

A NORTHERN RECORD FOR THE PACIFIC RIDLEY, *LEPIDOCHELYS OLIVACEA*.—On October 10, 1957 John R. Sandretto of Eureka found a marine turtle on the beach near Table Bluff, Humboldt County, California at approximately 40°42'N and 124°16'W. This turtle was given to Humboldt State College where it was identified as a small Pacific ridley, *Lepidochelys olivacea*. The carapace length is 24.1 cm., the width 23.8 cm. From external characters it appears to be a female. Mr. Charles Shaw of

the San Diego Zoological Society verified the identification.

This record is a northward extension of the range of this species by about 800 miles, the northernmost prior record being off Tiburon Island in the Gulf of California. This is the first authentic record for California. The Humboldt coast is probably not a normal part of the range of *Lepidochelys*. However during 1957 the coastal waters in this area have been warmer than normal with the result that a number of organisms more typical of a southern fauna have been collected locally.

This turtle died about a month after capture. It has been placed in the Stanford University herpetological collection.—WARREN J. HOUCK and JAMES G. JOSEPH, *Humboldt State College, Arcata, California*.

**RECORD AND MEASUREMENTS OF A LEATHERBACK TURTLE FROM THE GULF OF MAINE.**—On August 10, 1957 Mr. Carroll Brown, a lobster fisherman, found a leatherback turtle tangled in a pot line. The pot was set a few yards off shore of the island of Vinal Haven in about 25 feet of water. The turtle was cut loose, gaffed in the right front flipper, and brought to shore. There it received injuries due to rough handling. On August 12 the Aquarium was asked if we wanted the turtle for our exhibits. On the promise that the specimen was "in good condition," a truck was sent to Vinal Haven and the turtle was in our 50 ft x 30 ft. deep outdoor turtle pool by 1 AM of August 14. The turtle had suffered a rather bad gaffing on the flipper. It had many superficial abrasions and also a badly discolored spot, no doubt a bruise from being dropped, about 8 inches in diameter on its left chest just under the flipper. Furthermore, the aqueous humor had ruptured from both eyeballs.

Leatherbacks are exceedingly difficult to adapt to the limitations of confinement. Their life in captivity depends on how long they can withstand self-imposed battering of running headlong into the walls of their tank. Our turtle pool has sloping sides which prevent headlong collision, and we had hopes of keeping this individual for some time. It was obvious, however, that this animal was in distress. It breathed at the surface every half minute or so, much more rapidly than other large sea turtles, and was sluggish and weak in its movements. Its superficial cuts seemed to be responding to tetracycline ointment treatment administered daily by Dr. Ross Nigrelli of the Aquarium staff.

On the morning of August 16, the turtle was

found dead. The turtle was weighed on a truck scale. Measurements (reported in centimeters) were made that afternoon. Weight, 635 lbs.; Sex, Male; Total length, 209; Total width across extended flippers, 237; Carapace length, straight line, 145; Carapace length, along curve, 150; Carapace width, straight line, 84; Carapace width, along curve, 109; Head length, 27; Head width, 21; Greatest body depth, 44; Greatest front flipper length, 107; Greatest front flipper width, 31; Front flipper length from wrist, 93; Greatest hind flipper length, 51; Greatest hind flipper width, 29; Greatest tail length (from posterior end of plastron), 63; Greatest tail width, 19; Tail length from cloaca, 21; Penis length, 41; Penis width, 5.7.

An autopsy performed by Dr. Nigrelli and his staff found that cause of death was severe hemorrhaging in both lungs. Evidently, this had been caused when the turtle was dropped on its left side by the fishermen in Vinal Haven. The digestive tract measured 1200 cm. in length. Of this length 132 cm. was esophagus and stomach that are not anatomically marked off from each other. The entire interior of the digestive tract from the inside of the mouth to the rear of the stomach is covered with stiff, spiny papillae which project rearward and are up to 9 cm. long. The entire digestive tract, the penis, the skull and brain, one front flipper, and sections of most of the vital organs were preserved.

The interior of the stomach yielded one bit of rock weed, *Fucus*. It is possible that this individual was attempting to feed on a lobster in the lobster pots when it became entangled. That this turtle is omnivorous would conform to previous observations. Nevertheless, it has not been emphasized that the speed, size and strength of this animal as well as its very powerful jaws armed with maxillary cusps might make this animal a formidable predator. We do not doubt that this animal might well be primarily a fish-eater, a suggestion supported by its pelagic habitat where fishes predominate. The sharp papillae in the mouth, esophagus, and stomach might serve some sort of holding function for active prey.

Observations of this animal in the field in New England waters are few. Babcock (1945, COPEIA (1): 46) gives four records of leatherbacks occurring in the Gulf of Maine with dates of occurrence from July 29 to August 9. Carr (1952, Handbook of Turtles) says, the leatherback is a summer straggler to northern waters and it does venture well beyond the limits of the warm Gulf Stream and comes in quite close to shore. Only a few of the older fishermen of Vinal Haven had

ever seen water.

Flesh from was frozen 18, 1957 thick and basted with salt, and fatless deep red narily ter the taste gaminess reported by AAAS Pu contrary, and CHRI ium, New

LONG STATES below on or subsp given in y column), fourth co snake was cludes on died dur having di included the most ten years States are 262). This the first preciate records, Symbols Zoo, GPM Moore, N PZ = PH SIZ = St

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ever seen a leatherback and then only in deep water.

Flesh from the pectoral region of the turtle was frozen at the time of dissection. On October 18, 1957 this meat was unfrozen, sliced 1 inch thick and broiled exactly like a steak, being basted with a mixture of butter, lemon juice, salt, and red pepper to avoid drying out this fatless flesh. The meat of the leatherback is deep red like fine, aged beef and it is extraordinarily tender. There is virtually no odor and the taste is like sirloin, but with a touch of the gaminess of venison. No ill effects of the kind reported by Buckley and Porges (1956 Venoms, AAAS Publ. No. 44) were experienced. On the contrary, this was a real treat.—CARLTON RAY and CHRISTOPHER W. COATES, *New York Aquarium, New York*.

**LONGEVITY OF SNAKES IN THE UNITED STATES AS OF JANUARY 1, 1958.**—In the list below only the maximum record for each species or subspecies is given. The age of each snake is given in years (second column) and months (third column), with the source of the record in the fourth column. An asterisk indicates that the snake was alive on January 1, 1958. This list includes only individuals still alive or those that died during the previous year. Snakes noted as having died during the preceding year will not be included in subsequent lists. Those interested in the most recent complete list of snakes living ten years or more in collections in the United States are referred to Perkins (1955, *Copeia* (3): 262). This list will be brought up to date as of the first of January each year. We would appreciate hearing from anyone having longer records, or ten-year records for other species. Symbols used are as follows: BdZ = Brookfield Zoo, GPM = George P. Meade, JGM = John G. Moore, NCM = North Carolina State Museum, PZ = Philadelphia Zoo, SDZ = San-Diego Zoo, SIZ = Staten Island Zoo.

<i>Agkistrodon contortrix latiscinctus</i> *	17	7	SDZ
<i>Aspis cerastes</i> *	10	5	SDZ
<i>Crotalus alrox</i> *	21	2	SDZ
<i>Crotalus horridus atricaudatus</i>	10	10	SDZ
<i>Crotalus horridus horridus</i>	21	9	NCM
<i>Crotalus viridis viridis</i> *	19	1	SDZ
<i>Drymarchon corais couperi</i> *	25	4	JGM
<i>Epicrates angulifer</i> *	19	2	SDZ
<i>Lampropeltis dolia amaura</i>	20	7	GPM

<i>Lampropeltis dolia triangulum</i> *	12	9	PZ
<i>Lampropeltis getulus getulus</i> *	10	6	PZ
<i>Lampropeltis getulus holbrooki</i> *	14	8	SDZ
<i>Loxocemus bicolor</i> *	15	0	PZ
<i>Naja melanoleuca</i>	29	1	SDZ
<i>Pituophis catenifer annectens</i> (albino)	17	7	SDZ
<i>Pituophis catenifer annectens</i>	16	5	SDZ
<i>Pituophis catenifer deserticola</i> *	10	8	SDZ
<i>Pituophis melanoleucus melanoleucus</i> *	17	5	SDZ
<i>Pituophis melanoleucus mugilus</i> *	11	11	BdZ
<i>Ptyas mucosus</i>	10	7	SIZ
<i>Python curtus curtus</i> *	21	10	SDZ
<i>Python molurus bivittatus</i> *	21	9	SDZ
<i>Python regius</i> *	12	9	PZ
<i>Rhinocheilus lecontei lecontei</i> *	16	1	SDZ

CHARLES E. SHAW, *Zoological Society of San Diego, P. O. Box 551, San Diego 12, California*.

**INDUCTED OVIPOSITION IN BATRACHOSEPS ATTENUATUS, AND INCUBATION OF EGGS**—Seventy gravid *B. attenuatus* were collected at Berkeley, California, and kept for one week at 17.5° C. and for a second week at room temperature. Although most of these salamanders were ready to lay, no eggs were deposited in the laboratory. Ten individuals were given subcutaneous implants of whole pituitary glands of larger salamanders (*Ensatina*, *Taricha*, *Aneides*). Four of these deposited eggs in 72 hours. Since the remaining implants were not effective, .015 to .05 cc of pregnant mare serum gonadotropic hormone extract (Upjohn Co., Gonadogen, 1 cc equals 50 Cartland-Nelson Units) was given intraperitoneally at the rear of the abdominal cavity; oviposition followed in 72 hours. To determine whether pregnant mare serum would induce deposition when not preceded by implantation of whole pituitary glands, a fresh series was treated as follows; 5 received .015 cc of PMS, 8 received .02-.05 cc of PMS, and 5 received .015 cc of cold-blooded Ringer's solution. Three of the first group, all of the second, and none of the Ringer's-injected animals oviposited.

The eggs were incubated in amphibian hatching pots (Goin, Univ. Fla. Pub. Biol. Sci. 4(2): 1-66) at 17.5° C. and 21.0° C. with 90% hatch-

ing successfully in a mean time of 64 days. PAUL K. ANDERSON, *Museum of Vertebrate Zoology, University of California, Berkeley.*

**IRRUPTION OF YOUNG BATRACHOSEPS ATTENUATUS.**—It rained .75 inches Dec. 15–16, 1957, and .30 inches during the night of Jan. 24, 1958. At 7:00 AM, Jan. 25, air temperature 50° F., Mrs. Grant called my attention to numerous black "worms" on a low, white-washed cement landing and steps about two feet above ground level. Inspection revealed 103 tiny salamanders on a two square foot section of the wall and 55 others scattered on the wet steps and landing. They had apparently emerged through a crack 4 to 5 mm. wide between wall and landing. They were evenly distributed, fanning out from the crack. Head and body averaged 10 mm. in length, tail 6 mm. They were dark brown and scarcely visible on the wet ground. When an individual moved forward, it would advance a threadlike fore leg followed by the opposite hind leg that was always lifted higher than the level of the back; the fore leg was lifted less high. By 8:15 AM half had disappeared; by 9 AM, only 11 remained; by noon only 3 dead remained. Apparently some reentered the crack. It rained again lightly the morning of Jan. 26 and 11 were on the wall at 7:00 AM; a heavy shower washed them off, but by 10 AM, 7 had reappeared; at noon all had disappeared. —CHAPMAN GRANT, *R. 1, Box 80, Escondido, California.*

**A NOCTURNAL TENDENCY IN PHRYNOSOMA PLATYRHINOS.**—Four *Phrynosoma platyrhinos* were collected June 6, 1957, within a distance of .4 mile between 11:01 and 11:04 PM, in the Kramer Hills, San Bernardino County, California at an elevation of about 2,000 feet. The lizards, apparently asleep, were flattened against an abandoned asphalt road. When the car approached, they made no attempt to flee. The road was warm; the night air cool. The maximum temperature during the day at nearby Victorville was 89° F., while the minimum temperature that night was 64° F. The estimated temperature at 11 PM was about 70° F. Wind was negligible. Several other trips were made in this area, both before and after the above trip but no more specimens were taken at night.

On May 18, 1957 at 7:45 PM, from one to four miles east of San Luis, Sonora in Mexico, four more *Phrynosoma platyrhinos* were taken; three were DOR. The asphalt road was quite warm as was the air. Wind was negligible.

Although *Phrynosoma m'calli* has been reported to have some nocturnal nature, this is the first record of nocturnal tendencies in *Phrynosoma platyrhinos*. These records suggest that *Phrynosoma platyrhinos* is nocturnal.—ROBERT WESLEY HARRIS, *University of Southern California, Los Angeles, California.*

**A FIRST RECORD FOR TRIMORPHODON LAMBDA IN NEW MEXICO.**—The presence of the Sonora Lyre Snake, *Trimorphodon lambda*, in southwestern New Mexico has hardly been doubted. However, no specimens have been taken in the state. On August 19, 1957 Mr. T. O. Hendrickson and I collected a freshly killed specimen (CU 5583) at 4800 feet elevation on U. S. Route 260, two miles southeast of Glenwood, Catron County. Low, rolling hills of coarse gravel covered with desert-grassland vegetation dominated the surrounding countryside. *Prosopis*, *Juniperus*, *Yucca*, and *Opuntia* were widely scattered in the area.

Data on the specimen, a female, include the following: total length, 526 mm.; tail length, 81 mm.; ventrals, 238; caudals, 70; scale rows, 22-23-16; loreals, 2-3; preoculars, 3-3; postoculars, 3-3; supralabials, 9-9; infralabials, 12-11; temporals, 3-3; body-blotches, 24; tail blotches, 10. The blotches are fuscous brown with darker edges and light cream borders and centers. They are six scales long at mid body and separated by five scale interspaces. Noteworthy are the large number of ventrals and caudals and reduction of body blotches. The stomach contained a recently ingested *Sceloporus clarki*.

This record is not only an eastern extension of range for *lambda*, but also further herpetological evidence for the extension of the eastern limit of the Sonoran Desert into southwestern New Mexico. The range of this species as now known lies largely within the Sonoran Desert ecologic formation. It is quite possible that *lambda* has dispersed eastward along the Gila River drainage as *Heloderma suspectum* and *Micruroides euryxanthus* apparently have (Lowe, 1955, *Ecology* 36 (2): 343-5).—FREDERICK R. GEHLBACH, *Department of Conservation, Cornell University, Ithaca, New York.*

**MATING BEHAVIOR IN THE TREEFROG, Hyla versicolor.**—A premating behavior sequence of *Hyla versicolor* was observed on the flood plain of the Flint River at Newton, in extreme southwestern Georgia, on March 7, 1958. The observation, by means of indirect illumination from a headlamp, commenced at

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11:30 p.m. at an air temperature of 18.0° C., and a water temperature of 16.5° C. The night was still and overcast; some rain had fallen earlier in the day. Other species calling at the same time were *Bufo terrestris*, *Pseudacris nigrita*, *P. feriarum*, and *P. ornata*.

A strongly calling male *H. versicolor* was sitting 4 or 5 inches above the water in a small shrub at the centre of a shallow temporary pond. Loose, dead grasses around the base of the shrub formed a clump from 2.5 to 3.0 feet in diameter. Two female *H. versicolor* faced the male, one about 15, the other about 30 inches from it.

The nearer female started clambering on a circular path towards the male. The other female remained stationary and was not observed again. When about 4 inches from the male, the female moved some vegetation. The male immediately became aware of this and, still calling strongly, climbed up towards the movement. The female moved away a little before it continued the circling movement at a radius of some 5 inches; then it slowly approached, eventually contacting the male on one side. The male immediately clasped the female. The whole process required about ten minutes.

Observations were discontinued at this stage. The female was gravid; eggs appeared at the vent under the application of slight abdominal pressure.

From the distance and the direction travelled, with illumination only during periods of observation, it seemed conclusive that the female moved in direct response to the male call. This observation supports the general contention that the male call in Anura plays a primary role in attracting the female for mating.—MURRAY J. LITTLEJOHN, *Department of Zoology, University of Texas, Austin, Texas.*

**BULLFROG FOOD AND GROWTH AT THE SAN JOAQUIN EXPERIMENTAL RANGE, CALIFORNIA.**—Bullfrogs (*Rana catesbeiana* Shaw) were introduced in two reservoirs at the San Joaquin Experimental Range, O'Neals, California, in 1934; a good population has existed since that time. The artificial ponds often dry before the end of summer. When the ponds went dry on successive years, the life cycle from egg through metamorphosis was completed in about six or seven months (Fig. 1). Y. L. Willis, D. L. Moyle and T. S. Baskett. (*Copeia* 1956 (1): 30-41) cite references indicating that the



Fig. 1. In 1950 thousands of recently metamorphosed bullfrogs lined the shores of one of the earthen reservoirs at the San Joaquin Experimental Range, California. The eggs had been laid only about seven months earlier. This reservoir went completely dry during the late summer of the previous season.

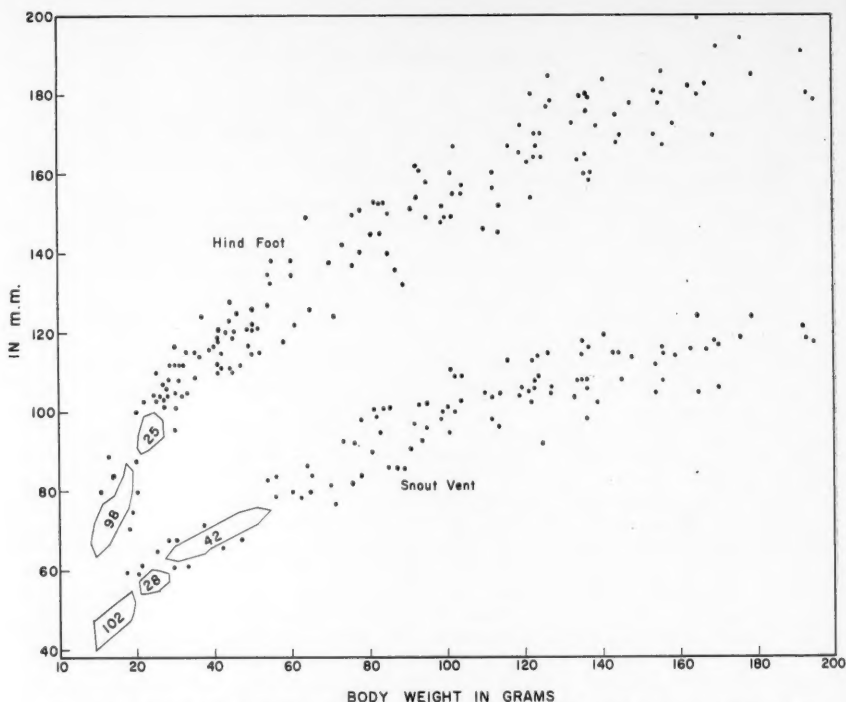


Fig. 2. Relationship between length of both snout-vent and hind-foot to weight of 274 and 278, respectively, bullfrogs from the San Joaquin Experimental Range, California. Where dots are too numerous to be drawn, the quantity of missing points are indicated.

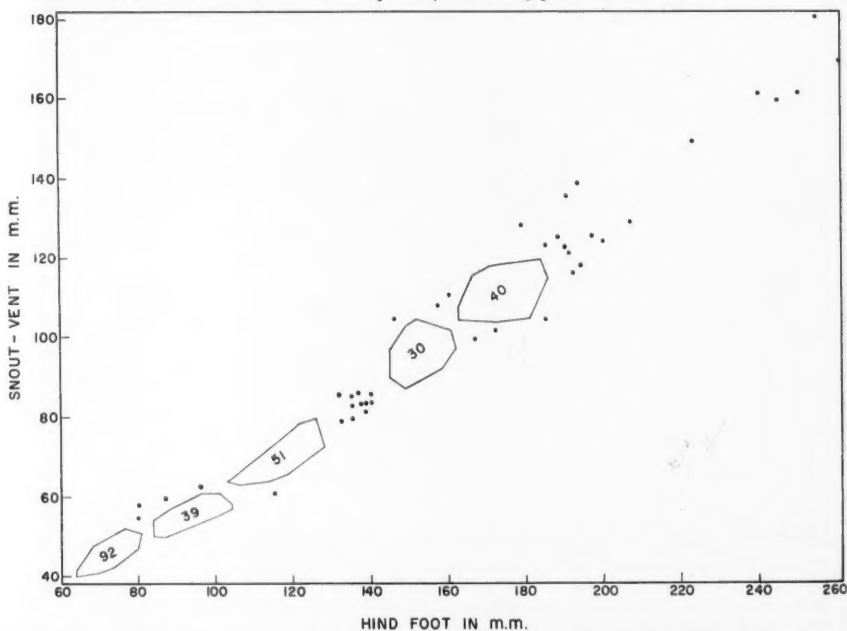


Fig. 3. Relationship between snout-vent and hind-foot lengths of 293 bullfrogs from the San Joaquin Experimental Range, California. Where dots are too numerous to be drawn, the quantity of missing points are indicated.

TABLE I  
STOMACH CONTENTS OF 300 BULLFROGS

Insects	Frequency*	Per-cent	Miscellaneous	Frequency*	Per-cent
COLEOPTERA	131	43.6	Decomposed tissue	54	18.0
Notonectidae	31	10.3	Spiders, Lycosidae	49	16.0
DIPTERA (Fam.?)	20	6.6	Rocks, grass, leaves, bark	33	22.0
HYMENOPTERA	19	6.3	Chitinous material	30	10.0
Locustidae	18	6.0	Snails, Planorbidae	27	9.0
EPHEMEROPTERA	13	4.3	Frogs	17	5.6
Gryllidae	13	4.3	Snails, Physid	14	4.7
PROTURA	10	3.3	Small fish	13	4.3
Chironomidae	8	2.6	Unknown vertebrates	7	2.3
Culicidae	6	2.0	Tadpoles	4	1.3
LEPIDOPTERA	4	1.3	Salamander	3	1.0
ODONATA	1	0.3	Feathers	3	1.0
Gerridae	1	0.3	Worms	2	0.6
Mantidae	1	0.3	Egg sack	1	0.3
Sepsidae	1	0.3	Rabbit pellet	1	0.3
Unidentified parts	64	21.3	Peromyscus	1	0.3

\* Number of stomachs in which food item was present at least once.

age of bullfrog tadpoles at transformation varies from four months (Louisiana) to three

years (New York) in the United States. Only gulf states were reported as having transformation occurring in less than one year.

The snout-vent and hind-foot relationships to weight for bullfrogs (274 and 278, respectively) are indicated in Figure 2. The few individuals too large to include in the graph fell within the projected curves. The relationship between the snout-vent and hind-foot lengths are indicated in Figure 3. All animals were collected in 1950-51.

The diet of 300 bullfrogs obtained from the San Joaquin Experimental Range appears to be omnivorous (Table I). The majority of these frogs weighed less than 200 grams (Fig. 2). Howard reports on an adult bullfrog capturing and eating a brown towhee (Copeia 1950 (2): 152).

When the ponds dry, the adult bullfrogs seek refuge in wells, springs and crevices of rock outcrops. When the rock dam of one of the reservoirs was destroyed in August, 1951, a total of 27 bullfrogs were recovered (N. W. Cohen and S. F. Wood. Bull. So. Calif. Acad. of Sci. 1953 (52), Part 1).—NATHAN W. COHEN and WALTER E. HOWARD, *Department of Physical and Biological Sciences, Modesto Junior College, Modesto, and Field Station Administration, University of California, Davis, California.*

## Ichthyological Notes

SIZE DISTRIBUTION OF FISHES IN A TEXAS ESTUARY.—Gradation in size of individuals from the upper region toward the mouth of an estuary has been shown for several animal species (see Gunter 1945, Publ. Inst. Mar. Sci. Univ. Tex., 1: 114-16, for a review of the literature and original contributions). A salinity gradient is also typical of estuarine waters. Thus, if there is an increase in size of individuals of a given species from the upper reaches of the estuary toward the mouth, and if the salinity increases from dilute to concentrated, a correlation between the two naturally obtains. But lest we misinterpret the correlation and conclude that animals are distributing themselves in response to the chemical nature of the environment, let us ask if salinity is the limiting factor in such distributions or if there is, more properly, a cause and effect relationship?

Studies of a Texas estuary, East Bay, near

Galveston, have yielded enlightening data on salinity in relation to size distribution of fishes. The investigations were associated with the excavation of Rollover Pass between the upper part of East Bay and the Gulf of Mexico. Both the studies and the excavation were projects of the Marine Division, Texas Game and Fish Commission, Rockport. The first of three summer studies was made in 1954, prior to the opening of the Pass, when the estuary was in its natural condition. The second study was accomplished in 1955 when the Pass was operating to greatly modify the nature of the Bay. Following the 1955 investigation, circumstances combined to necessitate the sinking of pilings across the Pass. This partial barrier decreased water flow through the Pass, resulting in a reversion of the Bay toward its original state. The results of the investigations, including descriptions of the area and techniques used, have been reported (Reid,

1955a, *Tex. J. Sci.*, 7: 316-43; 1955b, *ibid.*, 430-53; 1956, *ibid.*, 8: 296-327; 1957 *Limnol. and Oceanogr.*, 2: 198-212).

essentially constant under the three Bay conditions described. Of the major physico-chemical factors, water temperature and bottom composition ap-

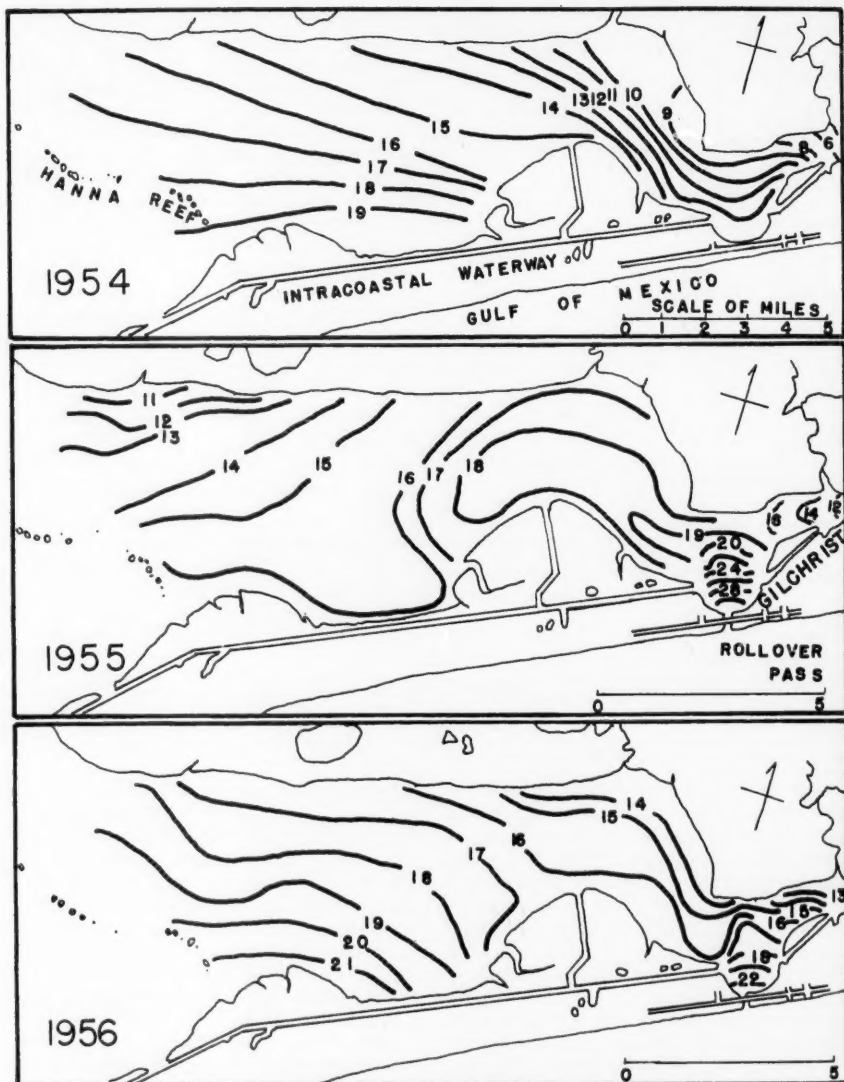


Fig. 1. Salinity distribution in East Bay, Texas, during the investigations of 1954, 1955, and 1956. The isohalines are based upon means at stations occupied and are expressed in parts per thousand.

In attacking the problem of size distribution of fishes in relation to environmental features, we are concerned both with those factors which noticeably varied and those which remained es-

peared to be basically stable during the three studies. Salinity distribution and currents varied significantly (Fig. 1).

The bottom in East Bay is predominantly mud

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except in the lower reaches where sand and shell have been deposited near a series of oyster reefs. In the upper area of the Bay the loose mud is from two to three feet thick. Towards the lower region of the Bay the mud layer is thinner and more compact. Diurnal surface temperatures during June ranged from 27.5° to 33.0°C in 1954, from 26.0° to 31.0°C in 1955, and from 26.5° to 31.0°C in 1956.

Precise measurements of tidal flow and currents were not made during all studies. It is obvious, nevertheless, that the normal pattern of regular tidal flow through the mouth of the

estuary by some animals in an estuary is an effect of a gradation of the salinity, what would be the result of reversing the salinity distribution? How would the size distribution of fishes be affected by changes in the salinity? The East Bay manipulations afforded opportunities to answer these questions, at least insofar as they relate to two species.

Samples of the Atlantic croaker (*Micropogon undulatus*), permit quantitative consideration. Collections used in deriving the data for a given year were made within a period of three weeks, therefore the role of growth as a factor is

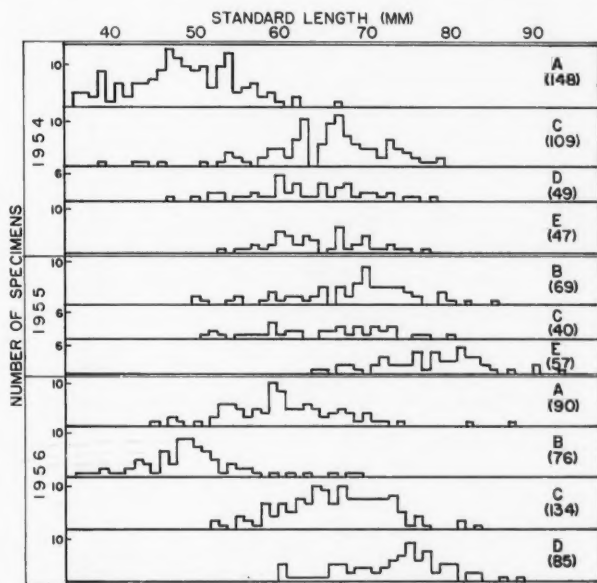


Fig. 2. Length-frequency polygons for the croaker (*Micropogon undulatus*) at various localities during each of the East Bay investigations (Fig. 4 shows the location of the groups indicated by letters). Numbers of individuals measured are shown in parentheses.

estuary toward the upper region of the Bay was greatly affected in 1955 by water movement through the Pass, and this was modified by the partial closure of the Pass after the 1955 study (Fig. 1).

More specifically, Figure 1 shows the magnitude of salinity change in the Bay during the three studies. The variation was considerable, especially in the upper Bay. The salinity near the head of the estuary increased from approximately 11‰ in 1954 to near 24‰ in 1955, and decreased from this high to around 17‰ in 1956. In the lower reaches of the Bay the salinity variation was less, ranging approximately four parts per thousand during the three investigations. If the size distribution gradient demon-

strated by some animals in an estuary is an effect of a gradation of the salinity, what would be the result of reversing the salinity distribution? How would the size distribution of fishes be affected by changes in the salinity? The East Bay manipulations afforded opportunities to answer these questions, at least insofar as they relate to two species.

Samples of the Atlantic croaker (*Micropogon undulatus*), permit quantitative consideration.

Collections used in deriving the data for a given year were made within a period of three weeks, therefore the role of growth as a factor is

<sup>1</sup> All of the fish measurements and population analyses presented in this report pertain to individuals in their first year. Insufficient numbers of older examples were taken to be of value.

mained similar to that of the previous year (Fig. 2), but reference to Figure 1 (1955) will reveal that the salinity in the upper part of the Bay was over two-fold that of 1954. During the 1955 study period the smallest croakers occupied the region of highest salinity.

Following the partial blocking of the Pass in

(*Leiostomus xanthurus*), met the conditions of frequency and abundance, and exhibited patterns similar to *M. undulatus*. Small spots were caught in the upper part of the Bay and older ones toward the mouth of the Bay, and the pattern correlated positively with the longitudinal distance and/or the salinity gradient in 1954 (cf.

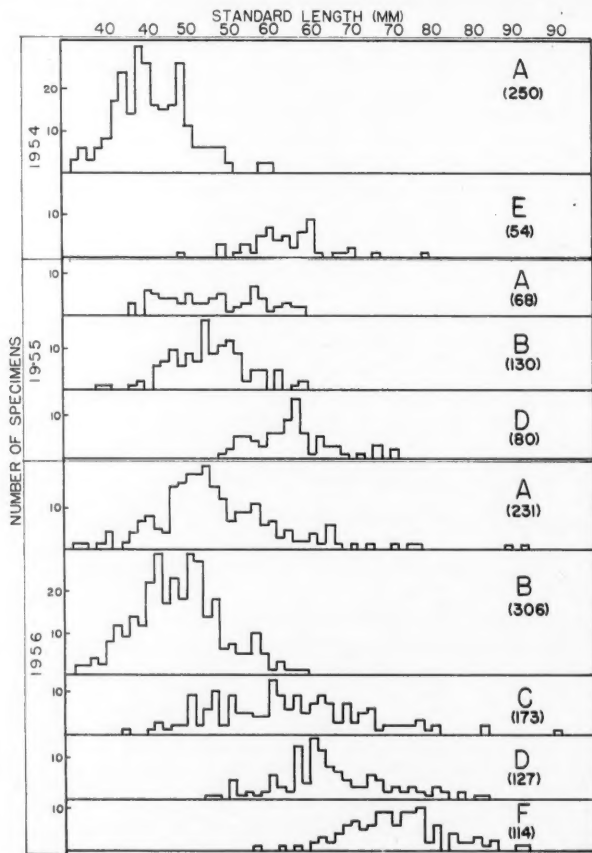


Fig. 3. Length-frequency polygons for the spot (*Leiostomus xanthurus*) at various sites within East Bay during each of the three studies (Fig. 4 shows locations of lettered groups). Numbers of examples measured are shown in parentheses.

the fall of 1955, exchange between Gulf and Bay was decreased. Thus, during the 1956 study, the salinity in the upper region of the estuary was approximately one and one-half times that of 1954. Figure 2 depicts the increase in size of the fishes from upper to lower Bay in 1956, but comparison with Figure 1 (1956) shows that the highest salinities were found in the upper Bay, although only slightly higher than near the mouth.

Another member of the Sciaenidae, the spot

(*Leiostomus xanthurus*), met the conditions of frequency and abundance, and exhibited patterns similar to *M. undulatus*. Small spots were caught in the upper part of the Bay and older ones toward the mouth of the Bay, and the pattern correlated positively with the longitudinal distance and/or the salinity gradient in 1954 (cf. Figs. 1 and 3). In 1955, while the Pass was in full operation, the fish were again distributed as in 1954 (Fig. 3), although the salinity pattern was essentially reversed from that of the preceding year. Furthermore, the pattern of size distribution of spots in 1956 paralleled that of croakers in the same year (Figs. 2 and 3) relative to both areal and salinity characteristics of the Bay (Figs. 1 and 3).

An interesting but unexplained corollary between the upper Bay size distribution of croaker

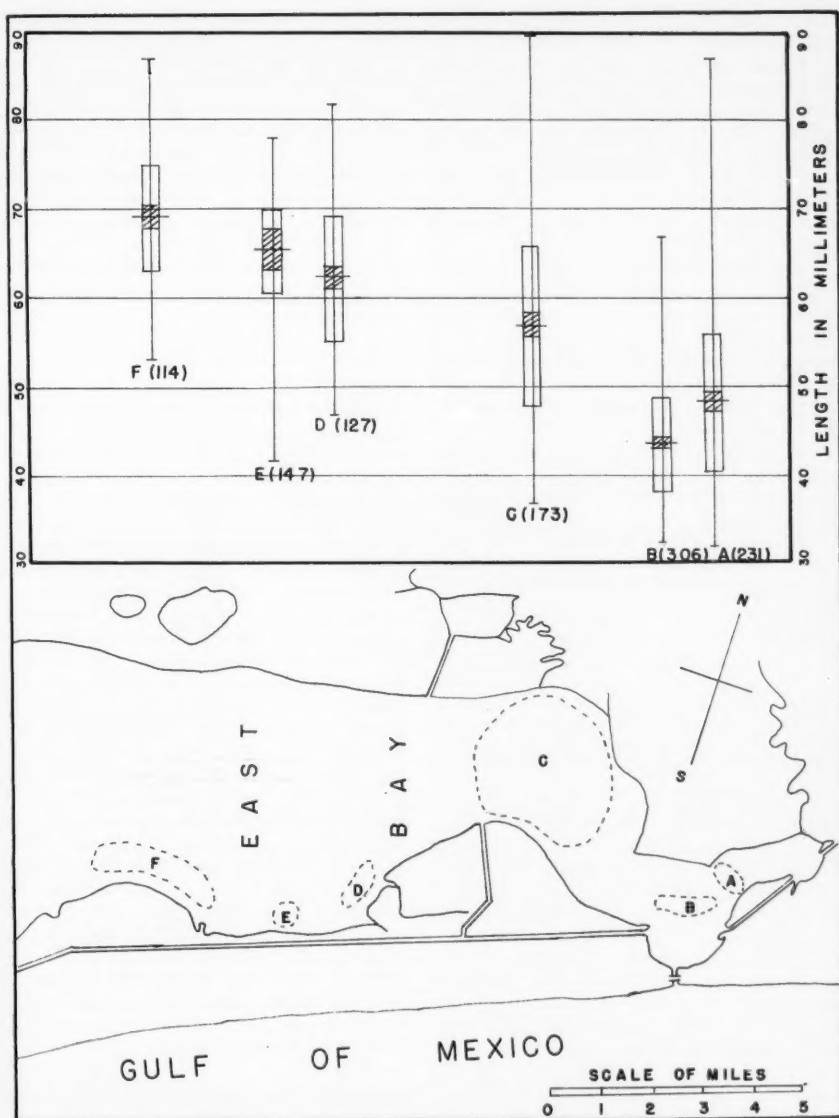


Fig. 4. Size distribution of the spot in East Bay, Texas, June, 1956. The single vertical line represents the size range in millimeters of standard length. Two standard errors on either side of the mean (horizontal bar) are shown as the shaded area, and one standard deviation on either side of the mean is described by the open rectangle. The numbers of examples measured in each locality are shown in parentheses.

and spot in 1956 is shown in Figures 2 and 3. The smallest individuals of both species were found at high-salinity locality "B" (localities are shown in Fig. 4). The individuals of the population segments of both species approximately one

mile up the Bay (site "A") were significantly larger, as were the segments nearly three miles down the Bay at site "C". The salinity difference in both directions from "B" was represented by a decrease of approximately two parts per thou-

sand. Tidal effects through partially blocked Rollover Pass, though slight, would be expected to decrease in the two directions as indicated by the isohalines in Figure 1 (1956).

We have suggested in the preceding paragraphs that the populations at the several localities were significantly different in terms of size of the individuals. One of us (Hoesé) subjected the 1956 data on *L. xanthurus* to statistical scrutiny (Fig. 4). That the inhabitants of the randomly selected sites are, within limits, different from one another (except for the overlap at "E") is strikingly shown. The over-all scheme, especially the segment at "E", indicates that there is intergradation of sizes within the estuary and that the distribution by size is clinal, with a relatively steep gradient. The mean of the sizes ranged from 43.6 mm. at "B" to 69.1 mm. at "F".

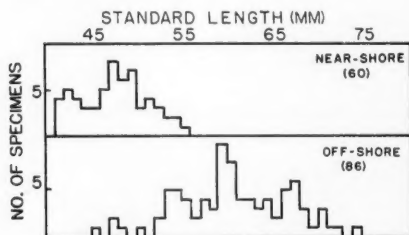


Fig. 5. Length-frequency figures for croakers taken in a near-shore collection (above) and an off-shore haul (below) near locality "A" (Fig. 4). Numbers of individuals are given in parentheses.

There are additional ways in which fishes of similar size may be distributed within the estuary. In 1956, two collections were made within a two-hour period in the vicinity of locality "A". One trawl haul near shore caught examples of *M. undulatus* ranging in size from 41 to 55 mm. (mean, 47.1 mm.), while another collection, made approximately one-half mile from shore, contained croakers from 45 to 74 mm. (mean, 60.2 mm.) long (Fig. 5). Variations in temperature, salinity, and bottom composition being minimal in the immediate area, it appears that depth is the important factor.

In Lake Pontchartrain, Louisiana, Suttkus (1954, Proc. Gulf and Caribbean Fish. Inst., Nov., 1954: 7) observed that specimens of *Microponogon undulatus* taken from along the north shore averaged larger than those taken from the south shore area. He suggested that young croakers group in the lake after they enter and remain in more or less discrete populations throughout the spring and summer.

In summary, our studies in East Bay strongly indicate that salinity, *per se*, is not the cause

of the size distribution cline of the two species studied. This conclusion is based primarily on the fact that the original, natural estuarine distribution pattern was maintained during two seasons in which the salinity gradient within the estuary was essentially reversed. Another aspect pertinent to the problem is that of the nature of the response of fishes to variations in salinity. In order for the spot distribution, in 1956 for example, to be affected by salinity, the fish would have to be acutely halitactic, since the magnitude of salinity variation between the populations was often no more than two or three parts per thousand.

#### DISCUSSION

The observed size distribution of fishes may be the result of the action of a single factor or of several interacting factors. The relative importance of factors or of the interrelationships thereof in the distribution of sizes is a subject for conjecture. Certainly food is important. During the summer the smallest croakers and spots feed primarily upon the organic detritus of the Bay bottom (Reid, 1955b), and this material is most abundant in the upper reaches of the Bay. As the fish grow they relinquish the detritus diet in favor of zooplankton and finally shift to shrimp and small fishes (croakers of intermediate size ingest the small pelecypod, *Macoma mitchelli*, with considerable frequency). Pearson (1929, Bull. Bur. Fish., 44: 204) stated that spawning by spots takes place near inlets and passes, followed by rapid migration of the young into the bays. If the young fish should move into the uppermost regions of the estuary in quest of basic food, and, after a period of growth, begin a slow, down-bay migration, feeding upon larger food items, the observed size distribution would result. Some support of our thesis on the increased richness of food materials in the upper part of the estuary is found in a report by Starr (1956, Ecology, 37: 658-64) in which he noted greater amounts of Vitamin B<sub>12</sub> in the detritus in the upper areas than in the lower reaches of Georgia estuaries.

If food is not a direct causative agent of size distribution, then a behavior pattern related to mode of immigration of newly-spawned individuals into the estuary may pertain. Should the first arrivals from the outer areas locate in the lower reaches of the estuary with later fish "leap-frogging" the earlier ones, the result would be a clinal scheme of decreasing size of the fishes from the mouth of the Bay toward the head.

Not all possible explanations for size distribution of fishes in an estuary have been sug-

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gested or explored in the present study. The phenomena of population growth and overcrowding, territoriality, and demographic aspects may, either singly or in combination, relate to the problem at hand.—GEORGE K. REID, *Department of Zoology, Rutgers University, New Brunswick, New Jersey*, and HINTON D. HOESE, *Department of Biology, Agricultural and Mechanical College of Texas, College Station, Texas*.

**WESTERN NORTH ATLANTIC RECORDS OF *BERYX SPLENDENS* LOWE AND *B. DECADACTYLUS* CUVIER AND VALENCIENNES.**—On the Atlantic coast of North America, there are three records of *Beryx splendens*. The first was caught by the U. S. Fish Commission R. V. ALBATROSS in 1885 (Goode and Bean, 1895, *Oceanic Ichthyology*, U. S. Nat. Mus. Spec. Bull. 177) off Savannah, Georgia. Two specimens were taken in 1955 by the U. S. Fish and Wildlife Service M. V. OREGON in the Gulf of Mexico (Woods, Copeia, 1957 (4): 298–299). Recently, two more specimens of *Beryx splendens* were caught by vessels that were otter-trawling for ocean perch (*Sebastes marinus*) in the northwestern Atlantic. Both specimens are deposited in The Museum of Comparative Zoology, Cambridge Massachusetts.

The U. S. Fish and Wildlife Service R. V. DELAWARE caught a 216-mm. (fork length) *B. splendens* on May 14, 1955, in 320 fathoms at 42°16'N and 65°07'W., which location is a few miles outside one of the Gulf of Maine's arbitrary boundaries that have been proposed by Bigelow and Schroeder (1953, U. S. Fish. Wildl. Ser., Fish. Bull., 53: 1). About 1,000 pounds of ocean perch were caught in the same tow. This specimen has dorsal IV, 14; anal IV, 29; pectoral I, 16; pelvic II, 13; and lateral line scales, 80. The depth of the body is 34.7 percent of the fork length.

The fishing boat FLO, captained by Percy Spurling of Rockland, Maine, caught a 419-mm. (fork length) *B. decadactylus* during the week of August 19–25, 1956, in 85 fathoms in the Gulf of Maine on Jones Ground, 40 miles east of Mount Desert Rock, Maine. The fish has dorsal IV, 18; anal IV, 28; pectoral I, 16; pelvic I, 10; and lateral line scales, 70. The depth of the body is 44.4 percent of the fork length. This is the first record of *B. decadactylus* in the western North Atlantic.

These species are cosmopolitan and found in moderate depths, usually on the border of the continental shelf (Bougis, 1956, Bull. Inst. Oceanogr., 891: 1).—LESLIE W. SCATTERGOOD, *U. S. Fish and Wildlife Service, Boothbay Harbor, Maine*.

**HIGH SALINITY MORTALITY OF DESERT PUFFFISH, *CYPRINODON MACULARIUS*.**—Cyprinodontiform fishes have been found frequently in shallow pools whose waters contained many dissolved solids (Miller, 1948, Mich. Univ. Mus. Zool. Misc. Publ., (68): 146; Steinitz, 1951, Nature, 167: 531; Smith, 1952, Ann. Mag. Nat. Hist., (12)5: 888). In a few instances the salinities were two to three times greater than that of the ocean although the ionic composition was different. Fox (1926, Trans. Zool. Soc. London, 22: 41–3) collected *Cyprinodon dispar* Rüppel (= *Aphanius dispar*) from brine pools at Kabret, Egypt; the salinities were equivalent to about 60‰ to 70‰. *Mollinesia latipinna* LeSueur, was abundant in water with salinities from 32‰ to 87‰, but absent when the salinity was 94‰ (Herre, 1929, Philippine Jour. Sci., 38: 121). Simpson and Gunter (1956, Tulane Stud. Zool., 4: 115) found *Cyprinodon variegatus* Lacépède to be plentiful at salinities as high as 80‰. They took a single live fish from water equivalent to 142‰; the only fish found in a pond with a salinity of 147‰ was one dead specimen. Coleman (1926, Calif. Fish and Game, 15: 227) quoted Mr. Hartley, of the Hartley Salt Works, Salton Sea, as stating that *C. macularius*, "...gets into their salt vats and will live in salt water up to 50 percent saturation, at which point it begins to die." This was a casual observation and should be regarded with caution: 50 percent saturation is difficult to equate for a heterogeneous salt solution but would be over 200‰. The few available records cited here indicate that the maximum salinity tolerance of cyprinodontiform fishes, with the exception of one specimen, is about 80‰ to 90‰.

On September 23, 1957, Dr. Otto Kinne and I visited the Salton Sea, California, to collect desert pupfish, *Cyprinodon macularius* Baird and Girard. These fish congregate in pools along the shore of the sea. Sometimes the pools become isolated from the sea and the salinity of the water increases as the water evaporates. One highly saline shore pool, which still contained pupfish, lay perpendicular to the shore rather than parallel to it as did the other pools. The pool was about 15 m. long, 2 to 4 m. wide, and 25 to 50 cm. deep, with almost vertical sides. The water at the surface was 36.1°C at 4 PM, which is shortly after the time of day of maximum temperature (Barlow, in press). The salinity was approximately 90‰ (freezing point –5.06°C; determined by F. W. Munz using a Fiske Osmometer). The color of the water was reddish-orange, a condition often associated with high salinity.

A much smaller pool lay between the first

pool and the sea. Marks on the sandbar showed that high waves often spilled into the tiny pool. The water in this pool was clear, suggesting a salinity much lower than 90‰. A water sample was not taken. A school of nearly 100 small pupfish was seen in the pool; they appeared to be in excellent condition.

At first only dead fish were found in the larger pool. Twenty-five freshly dead pupfish, 10 to 15 mm. in standard length, were floating at the surface. A few individuals of about the same size, and some larger fish, 20 to 30 mm. long, lay dead on the bottom. The larger fish were coated with a thin film of algae and apparently had been dead for a longer period of time than the smaller pupfish.

Ten live pupfish were captured with a fine-mesh seine. One of these was an adult female about 25 mm. long, and the other nine were juveniles about 10 to 15 mm. in length. All were extremely thin, swam feebly, and had difficulty maintaining equilibrium. The one adult was especially feeble. The fish were transferred to Salton Sea water (about 30‰) for transportation to the laboratory. The large female died shortly after being transferred, but the smaller fish survived and recovered completely.

The high salt content of the water probably caused the death of these pupfish; however, it is difficult to assess the role of the other environmental factors. In this instance the density of the fish population was low, when compared with earlier observations, and the food supply appeared to be adequate. Therefore it seems likely that the emaciated appearance of the fish was caused by osmotic dehydration rather than starvation. Disease was ruled out by the quick recovery of fish transferred to less saline water. Nor was the temperature lethal, because this fish can tolerate temperatures higher than 36°C at lower salinities (Barlow, in press). Further, the water of the smaller and less saline pool must have reached a higher temperature than that of the larger pool and yet there were no dead fish in the small pool. Thus it may be concluded that the maximum salinity tolerance of young *C. macularius*, in the field, is approximately 90‰; that of the adults is probably somewhat lower. This is in reasonable agreement with the known salinity tolerances within this group of fishes.—GEORGE W. BARLOW, Department of Zoology, University of California, Los Angeles, California.

**A CONCENTRATION OF THE RATFISH, *HYDROLAGUS COLLIEI* CAPE ARAGO, OREGON.**—On June 26, 1957, a concentration

of the chimaerid fish, *Hydrolagus colliei* (Lay and Bennett), was observed in the mid-tide and low-tide zones at South Cove, Cape Arago, Coos County, Oregon. Specimens were collected on a low tide of minus one foot at about 5:00 AM. Several were found trapped in the tide pools among rocks in the mid-tide zone; some were swimming slowly, others were dead. One male specimen, taken from the bay, was first seen swimming slowly at the surface. Ten specimens were noted in all, about equally divided between males and females. The bay was extremely cloudy and a great deal of wood pulp and sawdust was washed ashore and floating on the surface. Large numbers of juvenile rockfish, *Sebastes* sp., were also found, some stranded and dead, others swimming in the tide pools. Most of the rockfish in the pools were living. The water in the pools was clearer than that in the bay.

Egg cases of *Hydrolagus colliei* were first noticed by Mr. Robert Bayly who found one protruding from an oval opening of a female collected in a tide pool. One egg case was removed in the field, and several others in the laboratory. In each the case was in position for the large end to emerge first. Clemens and Wilby (1946, Fisheries Research Board of Canada, Bull. 68: 72) reported that Dr. A. L. Pritchard had observed such cases "set upright in the mud in the intertidal zone in Massett inlet." Possibly the ratfish noted at Cape Arago were part of a spawning concentration.

On the same day a party was trawling on the bottom about four miles off shore from the mouth of Coos Bay, at a depth of 27 to 30 fathoms. Mr. Lyle Jenkins, of the Oregon Institute of Marine Biology, reported the capture of a number of individuals of *Hydrolagus colliei* along with several egg cases.—HARRY G. M. JORSON, Bridgewater College, Bridgewater, Virginia.

**RECORD OF A HATCHERY-REARED RAINBOW TROUT, *SALMO GAIIRDNERI* GAIIRDNERI, WITH THREE PELVIC FINS.**—On April 26, 1954 at the U. S. Fish and Wildlife Service Fish Cultural Station, Winthrop, Washington, a yearling rainbow trout was found which had three pelvic fins. In formalin it was 16.9 cm. in total length. The third pelvic fin was located between the normally placed pelvics, and appeared to be normal in every respect. The pelvic girdle appeared normal in the X-rays.

The specimen, X-rays, and photographs have been deposited in the U. S. National Museum, Washington, D. C., No. 174970.—GALEN H. MAX-

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FIELD, U. S. Fish and Wildlife Service, Seattle, Washington.

**MOUTH SIZE AND FOOD SIZE IN YOUNG RAINBOW TROUT, *SALMO GAIIRDNERI*.**—Allan (1941, Jour. of Anim. Ecol., 10: pp. 47-76) pointed out that the behavior, as well as the size of an organism, will govern its availability as food for fish. Northcote (1954, COPEIA, (1): 25-8) showed a correlation between mouth size and diet composition in two species of *Coltus*. Experiments were conducted to determine the extent to which mouth size of young rainbow trout limited their feeding on various types and sizes of organisms.

Experiments were carried out during July and August of 1953 and 1954. Wild trout from Loon Creek, near Clinton, British Columbia, were used in all tests. Fish were retained without food for 72 to 182 hours in troughs 10 feet by 1½ feet, set in the stream bottom. Water depth in the troughs was 6 inches and the flow was less than 0.5 feet per second. The entry of macroscopic food particles was prevented by fine screening. During each trial three unfed fish of approximately equal size were transferred to a separate compartment in which had been placed food organisms of one type. The following three types of food organisms were tested: rainbow trout fry, caddis fly larvae, (Trichoptera) with the cases removed, and stonefly nymphs (Plecoptera). The size range of food organisms used was such that some were small and easily ingested and others were too large to be swallowed by the particular fish introduced. As soon as a fish swallowed or attempted unsuccessfully to swallow an organism, the fish and the experimental prey were preserved. Later the maximum width of the organism and the width of the fish's mouth at the posterior tip of the maxillaries were recorded. Measurements on the insect larvae and nymphs were made across the thorax. Head depth was measured on trout fry used as experimental food.

Figure 1 A shows the results of tests in which trout fry were offered to larger young trout. Mouth widths of the predator trout are plotted against head depths of the trout fry eaten or rejected. Points denoting successful ingestion fall near the 45° line, indicating a near 1:1 ratio between mouth width and maximum food width. Evidently the size of trout fry which could be swallowed whole was limited directly by the size of the predator's mouth.

Figure 1 B shows the results of tests in which larvae were offered to trout. The largest caddis larva taken by a trout of a given size in most

cases falls somewhat below the 45° line. Fish encountered considerable difficulty in trying to swallow relatively large caddis larvae. Smaller

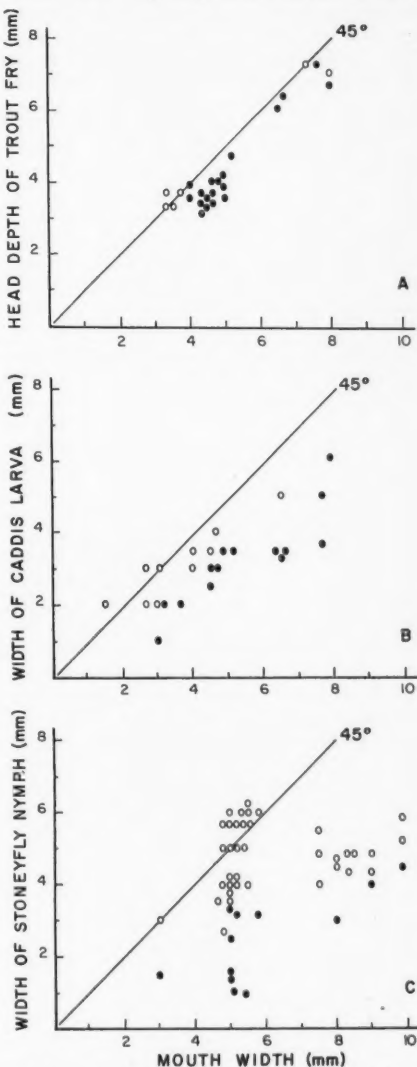


Fig. 1. Relation of mouth width of rainbow trout to maximum width of food organism eaten (solid circles) or rejected (open circles).

larvae were usually seized by the posterior end and swallowed, but large larvae showed a tendency to claw or anchor themselves to the nose of the fish. This behaviour often resulted in the rejection of the larva by the young trout.

Figure 1 C shows the results of experiments

using stonefly nymphs as food. Widths of largest nymphs swallowed fall well below the 45° line, indicating that fish encountered more difficulty swallowing stonefly nymphs than caddis larvae or trout fry of similar size. When seized by a fish, stonefly nymphs anchored themselves to the jaw of the predator and attempted to crawl free. Some nymphs that disappeared into the mouth of a fish were subsequently rejected alive.

The three organisms offered varying degrees of resistance to ingestion by trout. Trout fry were smooth and easy to swallow. The caddis larvae had short slender legs and offered some resistance. The stonefly nymphs had long strong legs and were active and difficult prey for young trout. This experiment indicates that although mouth size imposes a limit on the size of food swallowed, the structure and reactions of food organisms may result in a considerable discrepancy between width of the prey and mouth width of the smallest fish which can prey upon it.—G. F. HARTMAN, *British Columbia Game Commission, Department of Recreation and Conservation, Vancouver, British Columbia, Canada.*

**A SUMMER SILENCE OF SEA ROBINS, *PRIONOTUS* SPP.**—A conclusion that sea robins (*Prionotus evolans* Linnaeus and *P. carolinus* Linnaeus) produce two different calls is based partly on indirect evidence (Moulton, 1956, *Biol. Bull.*, 111: 393-8). The staccato call thought to characterize the breeding season of these fish at Woods Hole, Massachusetts, has not been heard from captive specimens, although it is thought to be spontaneously produced by individuals of a large group of the two species in a live car. The characteristic and more familiar grunts of these species are readily elicited and are often produced spontaneously in captivity. Anatomical considerations, sounds obtained on physiological stimulation of the air bladder muscles, data on the sounds of other kinds of fishes, and extensive sampling of the summer fish population in Great Harbor, Woods Hole, have indicated that male and female sea robins are responsible for staccato calls recorded and studied extensively at Woods Hole during the summers of 1954 and 1955. The most interesting aspect of this latter calling is the possibility of eliciting it by playing into the water imitations and recordings of the call (Moulton, 1955, *Bull. Ecol. Soc. Amer.*, 36: 80; 1956; Moulton and Backus, 1955, *Fish. Circ.* 17, *Me. Dept. Fisheries*).

In 1954 and 1955, staccato calls were heard on every day of listening from August 10, 1954, when the first calls of the summer were heard, to August 25, and July 5 to August 30, 1955.

The author was away from Woods Hole during the summer of 1956, and returned to the problem of these calls, in connection with other work, in 1957. From June 26 to the last week in August 1957, a single staccato call was heard on the morning of July 22, contrasted with hundreds during equivalent listening of the other summers. The single call followed immediately upon the playing into the water of a signal like those eliciting calling during the other summers. No spontaneous calls were heard during extensive listening periods throughout the summer of 1957.

While sea robins are ordinarily so abundant in Great Harbor during the summer months as to lend doubt to the possibility of their scarcity in 1957, this tentative conclusion seems merited. Although the raft from which listening was performed was anchored in a different position in 1957 than during 1954 and 1955, all three positions were within a radius of 250 yards from a common center, and the depth varied from 54 to 70 feet, with the 1955 position being intermediate. It seems unlikely that change in position alone furnishes an explanation for the absence of staccato calls in 1957.

A more reasonable explanation would seem to lie in the possible absence in 1957 of a breeding population of sea robins in Great Harbor. Fishing from the raft during extensive periods on two weekend occasions failed to raise sea robins by techniques usually successful in obtaining them; conversation with personnel of the supply department of the Marine Biological Laboratory indicated that several kinds of fishes ordinarily common close to shore were difficult to obtain last summer; this evidence and that of local fishermen have indicated that adult sea robins were not commonly caught in Great Harbor nor close to shore generally in the Woods Hole area last summer, despite the fact that during the last half of August young sea robins of between 1½ and 3 inches were common in shallow water off Nobska Beach, facing on Vineyard Sound. While the drought of the early part of the summer of 1957 may be related to a scarcity of sea robins in Great Harbor during July and August, a more likely explanation may lie with unusually high water temperatures at Woods Hole last summer.

Records obtained from Dean Bumpus have shown that from January on in 1957, January being an exception, the mean monthly water temperatures were above 70 year means for the Woods Hole area (Bumpus, 1957, *USFW Serv. Spec. Sci. Rep.*, Fish., No. 214) and that in June, the mean monthly temperature was nearly

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4 degrees C. (3.7) above the 70 year mean for that month. Fishing records and acoustical data seem to bear out the relative absence from Great Harbor during the summer of 1957, of a fish population apparently abundant there in 1954 and 1955.

Despite disappointing incidence of sea robin calling, and following the single reception of July 22, a trip was made to the summer's source of sea robin supply, the area between Menemsha Bight and Gayhead, Martha's Vineyard, on July 25 for underwater listening in an area where sea robins were then relatively abundant, to judge from dragger catches. Unfortunately an electronic difficulty and the noise of the several draggers then present over the fishing grounds prevented clear listening and recording, so results were inconclusive. Sea robins of both species contained in a live car hung from the raft in Great Harbor were in ripe condition until mid-August, yet no calling was heard before or subsequent to the single call of July 22, 1957.—JAMES M. MOULTON, *Bowdoin College, Brunswick, Maine, and the Woods Hole Oceanographic Institution, Woods Hole, Massachusetts*. Contribution No. 960 of the Woods Hole Oceanographic Institution.

**A CASE OF POISONING BY THE LION FISH, *PTEROIS VOLITANS*.**—At 9:00 AM, December 12, 1957, Edward Dols, an employee of the New York Aquarium, was cleaning a 100-gallon tank in which are kept three 5-7 inch lion fishes, *Pterois volitans*, with a small golden-striped bass, *Grammistes sexlineatus*, and a hawkfish, species unidentified. The movements of the rather nervous hawkfish seemed to frighten the smallest lion fish and as a result three dorsal spines of the latter penetrated Dols' right thumb above the second phalange to a depth of at least  $\frac{1}{8}$  inch. As he withdrew his hand from the water he noticed that the wounds were bleeding, and felt a burning sensation that almost immediately became extremely painful. Within three minutes from the time of the sting his hand had become very hot and red, and had started to swell noticeably. Five minutes after the sting he could not feel cold water running over his hand. Ten minutes after the sting, when on his way to the hospital, the pain had increased to the point of being almost unbearable. Dols could not sit still and there was a definite tendency to want to roll on the ground. He thrashed about and hit the floor boards of the car with his feet violently. At the hospital, 15 minutes after the sting, his hand had swollen to twice normal size and it could not be touched with-

out considerable pain. The entire arm was sore and some pain was noticeable in the neck and pectoral region. Penicillin, epinephrine and toxoid were administered and within 15 minutes the pain began to subside to the point of being bearable. By 9:40 AM, Dols returned to the Aquarium, though still in considerable pain. Although most of the swelling was gone by 10:00 AM, deep pain and stiffness of the thumb persisted until the next day. Some pain was noted six days later.

It is clear the *Pterois* is a dangerous fish. Were it not for very prompt treatment, Dols' condition might have become critical. He reported that he had brushed against the spines of this fish before and had not felt anything more serious than a mild stinging sensation, similar to the sting of a long-spined sea urchin, *Diadema*, which disappeared in a few minutes. There has been a tendency to underestimate the seriousness of the poisonous nature of this fish. Some ichthyologists and dealers in marine tropical fishes report, irresponsibly we believe, that the sting is not serious. However, stings may range from scratches from a single spine to deep wounds from several spines. In the latter case, we believe that this fish is capable of causing death to humans, either directly or through shock. The symptoms recorded here are in close agreement with those produced by the Stonefish, *Synanceja*, as reported by Smith (1951, COPEIA (3): 207-9). In Smith's case intense pain began 5-10 seconds after the puncture and unbearable pain and swelling, and a desire to "roll on the ground" was manifest in 5-10 minutes. Perhaps the promptness and nature of treatment saved Dols from long-range effects like those reported by Smith.—CARLETON RAY and CHRISTOPHER W. COATES, *New York Aquarium, New York Zoological Society, Brooklyn, New York*.

**A PANAMANIAN GOBIID FISH, *MICROGOBIUS MIRAFLORENSIS*, FROM WESTERN MEXICO, WITH TAXONOMIC AND ECOLOGIC NOTES.**—The inaccessibility of western México to motorized travel has thwarted biological exploration. As a result, the fish fauna of its Pacific coastal streams and lagoons has received little attention; indeed, that of most of Middle America is poorly known. Enough material has accumulated, however, to indicate that certain Pacific elements of the Middle American coastal fish fauna extend at least as far northward as Guerrero.

The goby reported below is a little-known species heretofore taken only in a few localities on the Pacific slope of Panamá. Lack of records

in the more than 1800 miles of intervening coastline serves to emphasize our ignorance of the distribution of fishes over that area.

*Microgobius mirafllorensis*

*Microgobius mirafllorensis* Gilbert and Starks, 1904, Mem. Calif. Acad. Sci., 4: 176-77, pl. 29, fig. 54 (original description; type locality: Río Grande, Miraflores, Panamá). Fowler, 1916, Proc. Calif. Acad. Sci., 68: 412 (1 specimen, Pacific slope of Panamá). Breder, 1927, Bull. Amer. Mus. Nat. Hist., 57 (3): 143 (280 examples from Río Chucunaque and Río Tupisa, eastern Panamá; life history notes). Meek and Hildebrand, 1928, Field Mus. Nat. Hist. Publ. 249, Zool. Ser. 15 (3): 873 (4 specimens, Río Culebra, trib. Río Bayano, Panamá).

This distinctive species of *Microgobius* is represented by 2 females (20, 27 mm. S. L.) and 1 male (21 mm.), UMMZ 167568, seined by M. A. Newman and H. R. MacMillan from a tributary of Laguna Papagayo (or Tres Palos), about 15 miles SE of Acapulco, Guerrero, México, on February 9, 1954; and by 7 males (24-31 mm.) and 5 females (25-29 mm.), UMMZ 173398, collected by R. R. and M. Miller on the southeast side of Laguna Coyuca, about 10 miles NW of Acapulco, on March 21, 1957. The original description was based on the holotype, evidently a male (a prominent genital papilla is present), 39 mm. in total length. When compared with the type by James C. Tyler, of Stanford University, a male from Laguna Coyuca, of almost the same length, agreed very well; two other males and a female were also examined by Tyler, and no significant differences were observed between them and Gilbert and Starks' account and specimen. I have compared all 15 specimens with the original description and figure, and find only slight differences such as variation in the length of the maxillary, length of the produced dorsal spines, and extent of squamation. These features in part result from sexual dimorphism and in part are normal variations expected from a series of specimens.

The diagnostic features of this species are: (1) absence of a cutaneous fold on nape and occiput; (2) comparatively large ctenoid scales (about 42-48 in longitudinal series); (3) produced dorsal spines, especially in males; (4) elongation of the maxillary, most pronounced in the male; and (5) a dark vertical bar on sides just below front of spinous dorsal fin, the body otherwise nearly plain except for 4 or 5 faint vertical lines.

Fin-ray counts in the Mexican specimens vary as follows: D<sub>1</sub> VII in 15; D<sub>2</sub> I, 16 (14), I, 17 (1); A I, 16 (14), I, 17 (1); P<sub>1</sub> 21 (7), 22 (6), broken (2); and C 16 (4), 17 (6), broken (5). The

caudal count is of the principal rays (branched plus 2 unbranched rays). There are 17 segmented caudal rays in 12 specimens (3 sent to Stanford University were not counted); this number agrees with that recorded by Ginsburg (1945, Copeia (3): 136) for five other species of *Microgobius*.

The new material demonstrates sexual dimorphism in certain characters: (1) mature males have a genital papilla which is lacking in adult females; (2) all but the first and seventh dorsal spines are produced but in males the filaments of the third and fourth spines extend from about the middle of the soft dorsal to well out onto the caudal fin, whereas in females the tips of the filaments fall short of the anterior third of the soft dorsal; (3) the length of the maxillary in males extends from a line drawn vertically through the posterior margin of the pupil (specimen 25 mm. long) to well beyond a line through posterior border of orbit (specimen 31 mm.), whereas in females this bone does not reach beyond a vertical line through the posterior part of the pupil and usually not beyond the middle of the pupil; and (4) the lateral bar beneath the front of the first dorsal fin extends ventrally to or well below the lower margin of the pectoral fin (when laid back against body) in males, but is noticeably weaker in females and does not extend to the lower rays.

The habitat at Laguna Papagayo was described by the collectors as fresh, turbid water to 2 feet deep over mud bottom, with water hyacinth and cattails along shore. At Laguna Coyuca, the water was fresh but murky (greenish-brown), the bottom sand, silt and mud, the immediate wind-swept shore flanked by a coconut palm forest; the 25-foot bag seine was hauled shoreward from a depth of 4½ feet through pieces of floating debris but no vegetation. The temperature of air and water here was about 85°F. at 7 P.M. Both of these lagoons are mapped and described by Ramírez (1952, Rev. Soc. Mex. Hist. Nat., 13: 199-218), who included a list of fishes taken from them. He gave salinity readings of 0.4 to 0.9 grams of chloride per liter for Tres Palos and 0 to 0.4 for Coyuca, for samples evidently taken during the rainy season; in the dry season, variations of 2.2 to 4.4 grams per liter are recorded. Breder (*loc. cit.*) found the species "... only in tide water, over very soft flocculent mud, in which they lay half buried."

Species associated with *Microgobius* at Laguna Papagayo were the clupeid *Lile stolidifera*, an atherinid (*Thyrinops*), *Cichlasoma cajali*, two eleotrids, *Dormitator latifrons* and *Gobiomorus maculatus*, and a gobiid of the genus *Garman-*

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nia. Taken in the same seine hauls at Laguna Coyuca were *Lile stolifera*, *Galeichthys guatemalensis*, *Hyporhamphus patris*, *Poeciliopsis turrbarensis*(?), a species of *Lutjanus*, *Mugil curema*, *Eucinostomus gracilis*, *Oligoplites mundus*, *Gobionellus microdon*, a species of *Garmannia*, and *Achirus mazatlanus*. None of these species is restricted to fresh water but one primary freshwater fish, *Astyanax fasciatus*, has been taken in the lagoons, suggesting that part of the habitat may be permanently fresh. This is further indicated by the presence (in Laguna Coyuca) of *Macrobrachium tenellum*, a true freshwater shrimp (Fenner A. Chace, Jr., kindly identified this invertebrate). Laguna Coyuca is connected with the ocean at the onset of the rainy season, when the Río Coyuca breaks through the bar near its mouth. The general aspect of the fish community indicates estuarine conditions, for most of the species are euryhaline types and some salt-water forms (e.g., *Anchoa*, *Polydactylus*, *Caranx*, *Trachinotus*) are represented only by their young stages (see Gunter, 1957, COPEIA (1): 13-16). Breder (*loc. cit.*) found *M. miraflorensis*

in fresh but tidal water in eastern Panamá, associated with primary (characins, catfishes), secondary (poeciliids, cichlids) and euryhaline types. Meek and Hildebrand (*loc. cit.*) took it from "... a very muddy and slightly brackish tide stream." This goby occurs in fresh and brackish water but it has not been reported in sea water; consequently it does not afford an example of a marine species invading fresh water only in the juvenile stages (Gunter, *loc. cit.*).

Field work in México was made possible by a grant from the Horace H. Rackham School of Graduate Studies of the University of Michigan. I am grateful to Isaac Ginsburg for aid in identification and to James C. Tyler for comparison with the holotype.—ROBERT RUSH MILLER, Museum of Zoology, University of Michigan, Ann Arbor, Michigan.

DISTRIBUTION OF THE ATLANTIC BIGEYE TUNA, *THUNNUS OBESUS*, IN THE WESTERN NORTH ATLANTIC AND THE CARIBBEAN SEA.—Although the Atlantic bigeye tuna, *Thunnus obesus* (Lowe), was first

TABLE I  
RECORDS OF ATLANTIC BIGEYE TUNA

No.	Locality	Date	Number Taken	Size	Vessel or observer	Source
1	Margarita Isl., Venezuela		Several	Mostly 80-110 kg.	M/V BOSO MARU	Fernandez-Yepe and Santaella (1956)
2	Ponce, Puerto Rico & St. Croix, V. I.	Winter, 1955	Few		M/V SANTO ANTONINO, Capt. Archie Cross	Bullis & Mather (1956)
3	Ponce, Puerto Rico	Spring, 1955	1	180 lbs.	Rolf Juhl	Donald S. Erdman
4	Alta Vela Isl., Dominican Rep.	IV-21-'55	2	150 cm. 152 cm.	M/V OREGON	Bullis & Mather (1956)
5	Miami, Fla.	X-20-'55	2	140 cm. 123 lbs.	Charter boat, CHIEF	Al Pflueger L. R. Rivas
6	Miami, Fla.	XI-'56	1	160.0 cm. 168 lbs.	Charter boat?	C. R. Robins Al Pflueger
6A	Miami, Fla.	XI-11-'56	1	148.2 cm. 137 lbs.	Charter boat?	L. R. Rivas
7	29°42'N 77°12'W	X-19-'57	1	75 cm. 22 lbs.	M/V DELAWARE	J. L. Squire
8	31°16'N 77°12'W	X-18-'57	1	Head only	M/V DELAWARE	J. L. Squire
9	33°55'N 75°13'W	X-16-'57	1	138 cm. 135 lbs.	M/V DELAWARE	J. L. Squire
10	Ocean City, Md.	IX-4-'57	1	66 cm.	Yt. JOHNNY, J. Englesby	F. J. Mather, III
11	Ocean City, Md.	IX-6-'57	2	18 lbs.	Charter boats or yachts	Milton L. Dennis
12	Ocean City, Md.	IX-7-'57 IX-15-'57	3	16 lbs.	Charter boats or yachts	Milton L. Dennis
13	37°45'N 71°49'W	X-8-'57	1	136 cm. 120 lbs.	M/V DELAWARE	R. H. Gibbs, Jr.
14	38°12'N 70°00'W	X-4-'57	1	172 cm.	M/V DELAWARE	R. H. Gibbs, Jr.
15	42°18'N 64°02'W	IX-10-'57	1	125 cm.	M/V DELAWARE	R. H. Gibbs, Jr.
16	Bermuda Isl.		1-2		L. S. Mowbray	Louis S. Mowbray (1956)

taken from west of the Azores as recently as 1955 (Bullis and Mather, 1956, Amer. Mus. Novitates, No. 1765: 2), it is now apparent that the species is widely distributed in the western north Atlantic and probably in the Caribbean, also (Table I, Fig. 1).

In the Caribbean Sea, the species occurs off the islands of Hispaniola, Puerto Rico, and St. Croix, and probably off Venezuela. In addition to the captures in the former area mentioned by Bullis and Mather (*loc. cit.*) a

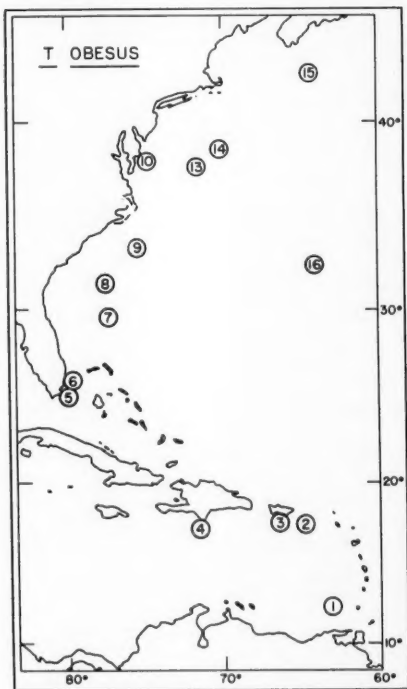


Figure 1. Locations of catches recorded in Table 1. Stations 11 and 12 are the same as 10.

180 lb. individual was taken off Ponce, Puerto Rico, in the spring of 1955. This was reported by Rolf Juhl of Ponce to Donald S. Erdman, who sent the information to us. Fernandez-Yepes and Santaella (Soc. Venez. Act. Submar., 1956, Publ. Ocas., Bol. No. 1: 23 pp.) mentioned the capture of several tunas, mostly 80-110 kg., off the Venezuelan island of Margarita. These were listed as bluefin tuna, *T. thynnus* (Linnaeus), but the measurements and photograph of a 145 cm. individual resemble *T. obesus* much more closely than *T. thynnus*. Specifically, the diameter of the eye, the length of the pectoral fin, and the depth of body are

all notably greater than the corresponding dimensions of an average western Atlantic bluefin of this size. Also, while nearly all the bluefins recorded from southern waters have weighed over 250 lbs., or less than 5 lbs., most of these Venezuelan tunas in question weighed from 175 to 245 lbs. It therefore seems likely that at least a large percentage of the fish from Venezuelan waters reported by these authors and other observers as bluefin tuna were actually *T. obesus*.

Recently the species has been identified among the catches of sport fishermen off Miami, Florida, and Ocean City, Maryland. Four caught off Miami and reported to us by Al Pflueger, taxidermist, and by Dr. C. Richard Robins and Prof. Luis R. Rivas of the University of Miami, were large individuals (123-68 lbs.). We have been informed, however, that 15 to 50 lb. Atlantic bigeyes are sometimes taken in considerable numbers off Ocean City. In 1954, for example, as many as 30 per day were said to have been taken by individual sportfishing boats in July. In other years they were most abundant in September. This information was received from Col. Milton L. Dennis of Ocean City, who said that he had reported this previously, but that his identification of the fish had been questioned. The fish taken September 4, 1957 was pointed out by Col. Dennis to one of us (Mather) as a bigeye tuna, and a thorough examination showed that his identification was correct. Col. Dennis was also familiar with the very similar blackfin tuna, *T. atlanticus*, and the bluefin tuna, both of which occur in this locality. Frank Stick of Kitty Hawk, North Carolina, has told us of the capture of some *T. obesus* by sport fishermen off Cape Hatteras.

The U. S. Fish and Wildlife Service M/V DELAWARE, in September and October 1957, took six bigeyes at long-line stations spaced along a zone from 25 to 140 miles outside the hundred fathom curve, extending from 42°18'N. latitude (off Browns Bank) to 29°42'N (off St. Augustine, Florida). One of us (Gibbs) was on the DELAWARE through the kind invitation of James L. Squire, of the U. S. Fish and Wildlife Service, and examined three of these individuals. The catch off Browns Bank is the northernmost record of the species for the western Atlantic.

It is notable that, with the exception of the reported "run" off Ocean City in July, 1954, all of the records from off the U. S. coast were in the months of September, October or November. Additional long-line fishing in deep water and a closer check on landings of sport fishermen should determine whether the species is definitely seasonal in the region.

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fishes of Bermuda," paper presented at International Gamefish Conference, International Oceanographic Foundation, Nassua, 1956: 8 pp.), one or two bigeye tuna have been definitely identified at Bermuda. He suggests that others may have been mistaken for the blackfin tuna, *T. atlanticus*, which is abundant there. Thus it is likely that the range of the western Atlantic individuals is continuous with that of those taken commercially off the Azores, Madeira, the Canary Islands, and the west coast of Africa.—FRANK J. MATHER, III, AND ROBERT H. GIBBS, JR., Woods Hole Oceanographic Institution, Woods Hole, Massachusetts. Contribution No. 942. Work supported by a grant from the National Science Foundation.

*GAMBUSIA SENILIS* FROM THE DEVIL'S RIVER, TEXAS, AN ADDITION TO THE FISH FAUNA OF THE UNITED STATES.—

The number of gambusiine fishes known to inhabit waters in the United States has increased rapidly in recent years. Prior to 1900 only *Gambusia nobilis* (Baird and Girard) and *G. affinis* (Baird and Girard) were recognized although many synonyms of the latter appeared in the literature. Geiser (1923, Amer. Midland Nat., 8: 175-188) reported *G. geiseri* Hubbs and Hubbs (as *G. senilis* Girard), from San Marcos, Texas. Differences between these two species are given in Hubbs and Springer (1957, Tex. Jour. Sci., 9: 279-327). A fourth species, *G. gaigei* Hubbs, was listed from Boquillas, Texas by Carl L. Hubbs (1929, Occ. Pap. Mus. Zool., Univ. Mich., 198: 1-11). Carr and Goin (1955, Guide to the Reptiles, Amphibians, and Fresh-water Fishes of Florida: 78) listed an undescribed species from southern Florida. Hubbs (1957, Tulane Stud., Zool., 5, 1-16) described *G. heterochir* Hubbs from Clear Creek, Texas. In this paper a seventh species, *G. senilis* Girard, is added to the known fish fauna of the United States.

Nine specimens of *Gambusia senilis* were collected from the Devil's River in Val Verde County, during a routine survey by W. H. Brown and other biologists of the Texas Game and Fish Commission. All are catalogued in the Texas Natural History Collection. Four (No. 5664) came from springs at the upper end of Devil's Lake, (Lat. 29°39'N., Long. 100°59'W.) on July 22, 1953. Another (No. 5689) was taken from the same locality on March 27, 1954. Four (No. 5675) were collected from the Devil's River just above the head of Devil's Lake on September 22, 1953.

The specimens are almost identical with a series of *G. senilis* from the Río San Pedro at Meoqui, Chihuahua, México, and the description of *G. senilis* in Hubbs and Springer (*op. cit.*).

The only difference is a slight fading of the mid-dorsal streak in the Texas specimens. All Devil's River specimens examined have 8 dorsal rays, 10 anal rays, 29 to 31 longitudinal scale rows, and 16 scale rows around the caudal peduncle. All females have the dark abdominal crescents typical of *G. senilis*, and none has a dark mark at the anus. The gonopodia of one mature male and one nearly mature male show: no recurved hooks on the elongate spines of ray 3; ray 4<sub>a</sub> reaching only to the terminal hook of 5<sub>a</sub>; two segments in the elbow; the distal serrae on 4<sub>p</sub> reaching to the middle of the elbow; and the terminal hooks on 4<sub>p</sub> and 5<sub>a</sub> rounded.

The Devil's River population of *G. senilis* probably does not result from recent human activities; however, the earliest material available from this segment of the river is after 1950 (Hubbs and Brown, 1957, Southwestern Nat., 1: 69-77). Introduction as discarded bait is unlikely, however, because either nearly 1000 miles of paved highway or over 100 miles of dirt track and 200 miles of paved highway would have to be traversed to carry fish from the Río Conchos, México, to the Devil's River. Moreover available bait fish in the Río Conchos would likely to be used locally in Lago Toronto. If not introduced, the fish must have been in the river prior to 1929, when the dams forming Lake Walk (about 34 feet high) and Devil's Lake (about 40 feet high) were completed. As the fish are not distinguishable from Mexican populations, a post-glacial connection is indicated. Hubbs and Springer (*loc. cit.*) proposed that the *G. nobilis* species group, which includes *G. senilis*, is being replaced by *G. affinis*. Whether the Devil's River population is a relict of such a wider range or is of more recent origin is uncertain. In the latter alternative individuals could have been washed downstream from the Río Conchos by floods prior to 1929 and gained refuge in the spring-fed waters of the Devil's River.

Although noteworthy, the presence of *Gambusia senilis* in the Devil's River is not unexpected. Hubbs (1957, Southwestern Nat., 2: 89-104) mentioned four other fish species which occur in Texas (and the United States) only in the Devil's River and adjacent streams. These fishes have Mexican populations or have near relatives that inhabit México.—CLARK HUBBS Department of Zoology, The University of Texas, Austin, Texas.

HERMAPHRODITISM IN THE CUT-THROAT TROUT.—Turner (1946, Chicago Acad. Sci. Nat. Hist. Misc., 1: 1-2) reported a case of hermaphroditism in the Yellowstone cutthroat trout (*Salmo clarki lewisi*) in Yellowstone

Lake, Wyoming. The fish, caught in 1944, had a normal left ovary and a short right ovary, and anterior to the right ovary was a small but rather perfect testis. Histological examinations showed that both the ovaries and testis were normal in the development of oocytes and spermatozoa.

A second hermaphroditic cutthroat trout was found in Yellowstone Lake on June 23, 1957, near the outlet at the northeast part of the lake. This fish had an arrangement of gonads different from that recorded by Turner.

The specimen collected in 1957 was 320 millimeters in total length and had a normal right ovary (88 mm. long) with all the stages of egg development. The left ovary was shorter (75 mm. long) but also had all stages of egg development.

Several eggs were loose and were the same size and color as those cutthroat eggs from normal ovaries. Both ovaries were attached by extensions of the mesovarium. Posterior to the left ovary was a well developed testis (30 mm. in length) which exuded milt. The testis was also attached to the mesovarium, although there was a sharp demarcation between the left ovary and testis. One partially developed oocyte was present in the mesovarian tissue around the testis. This fish was caught during the spawning season near a spawning area and the condition of the ovaries indicated that some eggs had been deposited before the fish was caught.—NORMAN G. BENSON, U. S. Fish and Wildlife Service, Logan, Utah.

## REVIEWS AND COMMENTS

THE PHYSIOLOGY OF FISHES. VOLUME 2—BEHAVIOR. Edited by Margaret E. Brown. Academic Press Inc., New York, 1957: xii + 526 pp. \$14.00—The first member of the dyad was reviewed in Copeia (1958, pp. 62–63). The ten chapters of the present work are more or less behavioral in scope.

The impression one receives from both volumes is that, in the main, the articles have been thoughtfully prepared and the literature has been reviewed well for the limited space available. Myron Gordon's article on physiological genetics should be required reading for everyone interested in systematics, especially for the evaluation of alleged hybrids. Regrettably, Brett's treatment of the eye was completed years ago, 1954 being the date of the most recent reference. Thus there is no mention of work done by Denton and Warren and Muntz on deep-sea fishes, which has shown that retinal pigments or chrysopsins of bathypelagic teleosts have a peak spectral sensitivity in the region of 475 mu. This corresponds with the wavelength band of light that passes through water with the least absorption, and also lies near the spectral emission peaks of many marine bioluminescent systems. One can hypothesize on the social significance of these coincidences, utilizing thoughts from quantum vision studies and information theory. (For a preliminary approach to this, see Denton and Warren, 1957, Jour. Mar. Biol. Ass. United Kingdom, 36: 651–62.) Perhaps the retinal pigments of other fishes are also adapted to the

environment. Brett (pp. 136–137) follows Wald's cleavage of the vertebrates into rhodopsin retinas (marine fishes and tetrapods) and porphyropsin retinas (freshwater fishes); it is realized there are exceptions, e.g. the marine *Tautoga* has porphyropsin. (Actually there appears to be a gradation from the porphyropsins through the rhodopsins to the chrysopsins, thus making the terms porphyropsin and chrysopsin superfluous.) Brett (p. 137) quotes Florkin, who wondered about the possible significance of the porphyropsin retina. A possible explanation for the presence of porphyropsin in fish eyes follows. As the turbidity of water increases, the wavelength of minimal light absorption shifts from 475 mu for pure water to 530 mu for turbid water. Fishes that live in turbid water should have their peak retinal spectral sensitivities shifted toward 530 mu, and such seems to be the case in diverse groups such as cyprinids, esocids and freshwater seranids; exceptions to this "rule" are found in such fishes as salmonids, but salmonids usually seek the clearest waters and light transmission would be maximal at wavelengths shorter than 530 mu. Other exceptions occur in surface-dwelling diurnal forms (e.g. *Fundulus*) where there is such an abundance of light that scotopic vision is seldom used and therefore it makes not much difference where the peak spectral sensitivity of the rods happens to lie. The relationship will probably not hold for nocturnal forms or forms that are poorly oriented visually.

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of volume 1 could have been judiciously condensed, not so with volume 2. Both volumes are highly recommended as reference works, and they would be unqualifiedly recommended for use as textbooks were it not for the high price.—VLADIMIR WALTERS, *American Museum of Natural History, New York.*

**SOUNDS OF NORTH AMERICAN FROGS.—**The Biological Significance of Voice in Frogs. Conceived, narrated and documented, with Recordings by Charles M. Bogert. FOLKWAYS RECORDS Album No. FX6166, Folkways Records and Service Corp., New York, 1958: Record 33 $\frac{1}{3}$  RPM, plus booklet of 17 pp., 61 figs., 1 map, 1 table, \$5.95.—Only a few years ago herpetologists were compelled to attempt reproduction of the fascinating vocal outbursts of anuran amphibians by recording the musical notes simulated or by some attempt to give a phonetic approximation of the call. In fact, in a recent issue of this journal, one author refers to a description of the call of a particular frog as "coat bet," adding that it doesn't sound at all like that to him, but is more like "toonk-tonk." Others might disagree with both authors and stoutly maintain the call sounds most like the name of a certain herpetologist spoken under water. Any effort to reproduce the vocalizations of frogs by means of phonetic symbols is fraught with many pitfalls and is, at best, a subjective reference.

Fortunately modern technological developments provide relatively uncomplicated devices for recording and audibly reproducing the calls of frogs with a high degree of accuracy and fidelity. In 1948 the Cornell album of records, "Voices of the Night," produced by Peter Paul Kellogg and Arthur A. Allen, was a pioneer venture of outstanding merit. The album contained recordings of 26 frogs and toads of the eastern United States on 78 rpm records. Later these were revised to include the calls of 34 forms, on a single long-playing 33 $\frac{1}{3}$  rpm record. Now Charles M. Bogert, Chairman of the Department of Amphibians and Reptiles of the American Museum of Natural History, has produced a 33 $\frac{1}{3}$  rpm, long-playing record that includes the calls of 54 named forms belonging to 48 species, plus one hybrid.

The material in both the record and the descriptive booklet is organized and presented so as to demonstrate the basic factors in the biological significance of voice in frogs. Here we can learn about: how frogs call; the function of amphibian vocalizations; mating calls, mating calls as isolating mechanisms; taxonomic levels and voice differences; sounds produced under special

conditions; territoriality calls; pitch in relation to body size; diversity in mating calls; and sample choruses. A list of popular references on North American frogs, a bibliography, an acknowledgment section and a biographical sketch of the recorder-author-producer is included in the booklet. Black and white photographs of all but three of the forms are included in the booklet—an excellent augmentation of the text and recordings. Shortly these pictures will be available in colored 2 x 2 inch slides for use with the record and can be obtained from the American Museum.

Through the use of modern recording and sound analysis techniques the quality and variation of frog calls can be demonstrated audibly on records or tape and visually by such means as the sonogram. These provide an objective method of studying and reporting accurately the vocal characteristics of individuals and populations, thus providing an additional tool for investigations of systematic relationships and speciation phenomena. Individual variation in call, changes in frequency produced by different temperatures, variation in pitch in relation to size of the frog, and geographic variation in quality all can be evaluated and reproduced accurately by the modern methods.

These facts are all brought out in Bogert's publication. In the book we read that in toads, for example, the marine toad (*Bufo marinus*), with an approximate male body length of 6.7 inches, has a call of approximately 600 cycles per second, whereas the call of the oak toad (*Bufo quercicus*) in which the male body length is about 1.1 inch has a frequency of about 5200 cycles per second. After reading this we can turn on the record and start with band 49 and continue to band 55 to hear seven toad calls of increasing frequency and decreasing size from the marine toad to the oak toad. In the booklet we see pictures of a barking treefrog (*Hyla gratiosa*) and a green treefrog (*Hyla cinerea*), plus a hybrid produced by a cross mating of these two. On the record in bands 18 to 20 we can hear the call of each parent species and that of the hybrid.

Either the record or the booklet can be used separately since each is filled with a surprising amount of information. In fact, the account presented in the book is the best and most comprehensive review of vocalization in amphibians that I have seen. Omissions, slips and typographical errors have been kept to a minimum. One minor inconsistency that I found slightly annoying is that species calling in the background are sometimes mentioned in the narration of the record, but are frequently not identi-

fied there. However, all are identified in the annotated list of sounds presented in the booklet. Thus for complete appreciation the record and book should be used together. In this way they provide a pleasant and enlightening source of information. We can remove doubts about the calls of the species recorded here and no longer worry about whether they are best described as "coat bet" or "toonk-tonk." We can all hear them as they really are.—JAMES A. OLIVER, *New York Zoological Society, New York.*

**BREVE NOTICIA SOBRE EL HALLAZGO DE ANUROS EN EL DENOMINADO "COMPLEJO PORFIRICO DE LA PATAGONIA EXTRAANDINA" CON CONSIDERACIONES ACERCA DE LA COMPOSICION GEOLOGICA DEL MISMO.** (A Short Note on the finding of Anuran in the "porphyritic complex of the extra-andean Patagonia" with considerations of Geological Compositions of the Same). By P. N. Stipaninc and O. A. Reig. *Revista de la Asociacion Geologica Argentina*, 1955: Vol. X, No. 4, pp. 215-233, 5 figs., 2 plates.—This short paper is one of the most important contributions to the phylogeny and systematics of frogs. Over a dozen specimens of a new leiopelmid-like frog, *Notobatrachus degiostoi* Reig, are described and discussed. Dr. Reig places this important fossil in a new family, the Notobatrachidae. This species is characterized by Dr. Reig by the following amazing array of characters: 1. 9 presacral amphicoelous vertebrae; 2. ribs present, articulating with vertebrae 2-5; 3. pectoral girdle firmisternal; 4. coracoid with a convex anterior border; 5. scapula not divided by a ventral notch; 6. clavicle longer than scapula; 7. cleithrum present; 8. 1 postsacral vertebra free or fused with urostyle (text erroneously states presacral); 9. astragalus and calcaneus separated; 10. carpus formed by 8 small bones; 11. prepollex present and rudimentary; 12. mandible with true teeth; 13. maxilla, premaxilla and vomer dentate; 14. frontoparietals separated by suture in the midline and articulating with nasals; 15. parasphenoids articulating with premaxillaries and prootics; 16. internasals present; 17. cranium relatively large, wider than long; 18. limbs short, femur longer than tibiofibula.

Of these characters, 1, 2, 8, 9, 10, 12, 14 and 18 are without doubt primitive characters in frogs. In fact, many of these features do not appear in any living frog. As a result we conclude that this Upper Jurassic frog is more primitive than any living frog and is one of the most primitive true frogs known. Yet it has a firmisternal girdle.

For some time it has been evident that the im-

portance of the pectoral girdle has been over-emphasized, and has perhaps been misinterpreted. It is now clear that it is erroneous to state that the firmisternal condition is advanced. In fact, it would appear that the opposite is true and that the firmisternal condition is actually primitive and that the arciferal condition is secondarily simplified.

In a recently arrived paper, Los Anuros del Matildense, (Acta Geol. Lilloana, vol. I, pp. 231-297) Dr. Reig has elaborated on his original study described above. As a result of these two studies we can say without doubt further changes will be made in our basic concepts of the primitive characters to be used in frog phylogeny. It is certain that new paleontological finds will alter many other of our preconceived ideas regarding the higher classification of the anurans.—MAX K. HECHT, *Department of Biology, Queens College, Flushing 67, New York* AND RODOLFO RUBAL, *Division of Life Sciences, University of California, Riverside, California.*

**FISKARNA I FÄRG.** By Kai Curry-Lindahl, illustrations by N. Norvil. Almqvist and Wiksell, Stockholm, Third edition, 1957: viii + 189 pp., 64 col. pls., 1 fig. 11 Kr.—This little book, produced for popular use in Scandinavia, serves its purpose well. The text provides handbook-type information on Scandinavian fishes and in this respect the book may deserve a niche in one's library.

Slightly fewer than 200 species of freshwater and marine fishes are illustrated in low quality color. On the first plate *Myxine glutinosa* is shown to have three separate gill openings on the right side instead of a single opening and on the last plate *Mola mola* and *Lophius piscatorius* resemble no individuals of these species the reviewer has seen; intentional or not, the artist has given *Lophius* a bleary-eyed expression. Leafing through the rest of the plates one notes particularly inaccurate representations of *Ameiurus nebulosus* (shape, color pattern), *Cypsilurus heterurus* (pectoral fins set at an impossible angle for flight), *Trachypterus arcticus* (shown scaled), *Regalecus glesne* (shown scaled), *Brama rai* (squamation erroneous), *Xiphias gladius* (color of iris), and *Sebastes marinus* (coloration).

There are no valid reasons for placing *Salvelinus* in *Salmo*, nor *Myoxocephalus* and *Taurulus* in *Cottus*.—VLADIMIR WALTERS, *American Museum of Natural History, New York.*

**ON THE DYNAMICS OF EXPLOITED FISH POPULATIONS.** By Raymond J. H. Beverton and Sidney J. Holt. Her Majesty Stationery Office, London, 1957: Ministry of Agriculture,

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Fisheries and Food, Fishery Investigations Series II Volume XIX. 533 pp.—Fishery biology has not yielded the contributions to general science that other fields of applied zoology have. Beverton and Holt offer a major contribution in this direction. Their book is a study of the interdependence of four primary processes determining size and structure of marine fish populations: recruitment, growth, capture, and 'natural' death. They are mainly concerned with the North Sea, and their practical purpose is the establishment of principles for a successful management of fisheries in that region. But even with this apparently limited scope, the authors find all kinds of data pertinent, ranging from biological phenomena such as growth of individual fishes and populations, seasonal and secular migrations, to the technical details of fishery equipment. Their framework of conclusions permits extrapolation in many directions. First, the derived views can be applied to other regions, where similar data are obtainable, or, if not, they show what data should be obtained and how they are to be evaluated. Secondly, the interrelations described can be transferred to any other kind of populations and therefore can (and undoubtedly will be) of paramount importance to any future work in population dynamics and ecology. Inevitably the nature of the processes discussed requires their description by mathematical formulas, and the nature of interdependencies between them again requires mathematical treatment. Thus, the book may appear on first glance more like a textbook of mathematics than one on zoology. However, the authors have provided a resumé in "plain English" and, by using this as a guide, the reader with a limited knowledge of mathematics, but with a basic understanding of mathematical thinking, will enjoy the clear and enlightening presentation of this complex subject. The authors have never allowed themselves to be carried away by the elegance of mathematical deductions and solutions from their original biological problem. The book is certainly not too easy reading for the less mathematically minded reader, but one gets the conviction that it is worth study by more than fishery biologists. The style, the printing, the format and the bibliography are attractive. This book represents eight years of work, and this seems, in view of the wealth of information, the degree of its digestion, and the

clearness of presentation of conclusions and results, a rather short time.

**FROM QUEENSLAND TO THE GREAT BARRIER REEF.** A Naturalist's Adventures in Australia. By Noel Monkman, F.R.M.S., Doubleday and Company, Inc., Garden City, New York, 1958.—Unlike the *Lady with the Spear*, Noel Monkman is not a scientist. A photographer with a very broad field of interests he knows a lot about natural history and how to tell it. Reptiles are represented by reports of net-caught and one air-traveling crocodile, and descriptions of a turtle laying eggs. Fishes are mentioned. The pictures are good. Of 53 illustrations, ten are colored, two of them—and many more of the black-and-whites—showing the author. The author's bias for microphotographs has kept him from including even one view of the Barrier Reef.

**FAUNA D'ITALIA: LEPTOCARDIA CICLOSTOMATA SELACHII.** By Enrico Tortonese, Fauna d'Italia vol II, viii + 334 pp. Edizione Calderini, Bologna, 1956.—The fish volume of the TNO, the Fauna of the North and Baltic Seas (Tierwelt der Nord-und Ostsee) seems not likely to be matched by a similar treatise on the whole Mediterranean. The student of this region still has to consult a number of nationally edited works, the ranges of which may (e.g. Soljan's *Fishes of the Adriatic*) or may not (e.g. Dieuzeide-Novalla's *Fishes of the Algerian Coast*) coincide with natural subdivisions of that sea. To this list of works in Spanish, Portuguese, French, and Serbian, Tortonese has added a volume of those lancelets, cyclostomes, and chondrichthyes observed in Italian waters. (In the last group, 60 out of 68 species recorded for the whole Mediterranean are reported on.) The book under review, which is to be followed by a treatment of bony fishes, is superlative and the Italians are to be congratulated on this achievement. The introductory sections on the individual groups are excellent and offer some of the best available brief accounts of this kind. The systematic parts, in addition to the usual factual and bibliographical data, include valuable biological information which forms a valuable complement to that in Bigelow and Schroeder's work on the Western North Atlantic forms.

## EDITORIAL NOTES AND NEWS

Stanford  
University

DR. AND MRS. GEORGE S. MYERS have received a three year National Science Foundation grant for the preparation of a systematic monograph of the deep-sea fishes of the order Zeomorphi. They will be in Europe this summer working at the British Museum and attending the *International Zoological Congress*. A longer European trip to study Zeomorph fishes in European museums is planned for 1959. In February 1958, Dr. MYERS was able to join GENERAL THOMAS D. WHITE, MR. LEE WULF and COL. JOHN N. REYNOLDS in Colombia for a week of fish collecting in the Rio Caqueta. A large collection, including a new family of catfishes, was secured. Collaborative work with Mr. LEVITON on South American frogs and on a basic bibliography on systematic and areal herpetology of the world is continuing. Dr. MYERS has recently acted on National Science Foundation panels for summer and in-service institutes for secondary-school science teachers and is serving on the A.A.A.S. steering committee for the *First International Congress of Oceanography*, to be held in New York during September 1959.

Under a National Science Foundation grant, Dr. D. E. WOHLSCHLAG is completing his study of seasonal changes in mortality, recruitment rate, growth rate and population size of bluegills in Felt Lake, on the Stanford Campus. Working under Dr. WOHLSCHLAG, DAVID A. FARRIS of the Fish and Wildlife Service has completed his doctorate thesis on the distribution and abundance of jack-mackerel, and ARNOLD GREEK, on a National Science Foundation fellowship, is completing studies of seasonal changes in bluegill metabolism.

Dr. ROBERT R. (HARRY) ROFEN, Director, and ADAIR FEHLMANN of the George Vanderbilt Foundation at Stanford attended the *Pacific Science Congress* in Bangkok in November 1957. While in Thailand they collaborated with the Thai Navy in making collections totalling over 20 barrels of fishes as well as many sea-snakes and other herpetological material. Dr. ROFEN recently published a review of *Kraemeria* and is now working on the systematics of Indo-Pacific gobies. FEHLMANN is working under Dr. MYERS on a doctorate thesis on the ecology of fishes in a small stream in the Palau Islands.

STANLEY A. WEITZMAN has completed his doctorate thesis on the systematics, osteology and inter-relationships of certain South American

characid fishes, under Dr. MYERS' sponsorship, and has received an appointment as Instructor in the Stanford Department of Anatomy. Other graduate students working with Dr. MYERS are BENJAMIN BANTA (Ecological Herpetology of Nevada), who recently received an appointment to the faculty of Pomona College for 1958-59; WARREN FREIHOFFER (Neurological Studies on Percomorph Fishes); ALAN E. LEVITON (A Monograph of the Snakes of the Philippines), who is now acting curator of the Dept. of Herpetology of the California Academy of Sciences; H. MÜNSTERMAN (Snakes of the Riu Kiu Archipelago); RICHARD FORD (Systematics of Blennioid Fishes); HUGH DEWITT (Fishes of Nepal); and SARAH THOMPSON (Studies on the Pectoral Girdle of Ranid Frogs).

Dr. ROLF L. BOLIN of the Hopkins Marine Station of Stanford, on sabbatical leave in Hong Kong, reports considerable progress in assembling material for a monograph on Hong Kong fishes. MARGARET BRADBURY has transferred from the Campus to the Marine Station, where she is continuing her revisionary work on Ogocephalidae. Dr. WALTER C. BROWN, Professor of Zoology in Menlo College and Research Associate in the Stanford Natural History Museum, left in April to return to Negros Island, Philippines, for three months more herpetological field work in collaboration with MR. ANGEL ALCALA of Silliman University, Dumaguete. Dr. BROWN and MR. FEHLMANN recently completed a paper on a strange new genus of arboreal scincid lizards from the Palau Islands.

The University  
of Texas

Dr. MURRAY J. LITTLEJOHN from the University of Western Australia arrived in late January to begin a year's tenure as a Fulbright post-doctoral fellow and part-time instructor in Zoology. His work in Australia was concerned primarily with speciation in the genus *Crinia*, and he is working here on hybridization tests in U. S. hylid frogs.

Dr. A. R. MAIN of the University of Western Australia visited in April and May. He is visiting laboratories in the United States on a Carnegie Foundation grant. Dr. MAIN is responsible for the development of a center of research on amphibian speciation at the University of Western Australia.

Dr. WILLIAM MCFARLAND will join the staff of the Institute of Marine Science as a marine

ichthyologist. MCFARLAND will be working with DR. HELLIER on production ecology of chains.

Dr. W. W. WOOD has received a three year National Science Foundation grant for a study of breeding habits of the California quail. This work will involve analysis of the quail's reaction to the environment to determine factors affecting its breeding habits. Dr. C. C. CLARK has received a three year National Science Foundation grant for a study of the factors affecting the breeding habits of the California quail.

Four Ph.D. students in the Department of Zoology are working on projects affecting the breeding habits of the California quail. Pseudoeurycea, a new genus of amphibian, was described by the University of California at Berkeley. The new genus, *Pseudoeurycea*, was described from the Sierra Nevada mountains. The new genus, *Pseudoeurycea*, was described from the Sierra Nevada mountains. The new genus, *Pseudoeurycea*, was described from the Sierra Nevada mountains.

Graduate students in the Department of Zoology are working on projects affecting the breeding habits of the California quail. The new genus, *Pseudoeurycea*, was described from the Sierra Nevada mountains. The new genus, *Pseudoeurycea*, was described from the Sierra Nevada mountains. The new genus, *Pseudoeurycea*, was described from the Sierra Nevada mountains.

WILLIAM MCFARLAND will join the staff of the Institute of Marine Science as a marine

ichthyologist and fisheries biologist in September. McFARLAND comes from UCLA, where he worked with DR. BOYD WALKER. At the Institute, TOM HELLIER, JR., is doing graduate research on mullet productivity. WALTER ABBOTT is studying production ecology and ROBERT BEYERS is studying food chains.

DR. W. FRANK BLAIR has received a renewal for three years of his grant from the National Science Foundation to study the factors affecting interbreeding of natural populations of amphibians. This work has three main aspects: (1) physical analysis of mating calls, (2) laboratory hybridization to test genetic compatibility, (3) field studies to determine ecological isolation mechanisms.

DR. CLARK HUBBS has received a renewal for three years of his National Science Foundation Grant for study on interbreeding of fish populations.

Four students have recently completed the Ph.D. in herpetological subjects. HAGUE L. LINDSAY wrote on "An analysis of variation and factors affecting gene exchange in *Pseudacris clarki* and *Pseudacris nigrita* in Texas," and is now at the University of Tulsa. RALPH AXTELL did, "A monographic revision of the iguanid genus *Holbrookia*," and is now at East Texas State College, Commerce. WILLIAM R. MEACHAM worked on "Factors affecting the interbreeding of two allopatric populations of toads," and is now at Arlington State College, Arlington, Texas. J. P. KENNEDY worked on "The biology of the eastern fence lizard, *Sceloporus undulatus hyacinthinus*."

Graduate students and their research problems in herpetology include: M. J. FOUQUETTE, Isolating mechanisms in three sympatric species of treefrogs (genus *Hyla*) in the Canal Zone; DON HUNSAKER, "Ethological isolation in the *Sceloporus torquatus* group"; CLIFFORD W. JOHNSON, Hybridization of "call races" of *Hyla versicolor*; HAROLD E. LAUGHLIN, Interspecific relations of some natural populations of lizards; WAYNE H. McALISTER, Vocal mechanics of toads; TED C. MICHAUD, Factors affecting mating call in *Pseudacris nigrita* and *P. clarki*; FLOYD E. POTTER, Biology of neotenic *Eurycea*.

Graduate students in ichthyology include: EXALTON A. DELCO, JR., on leave from Texas Southern University, will probably study the comparative behavior of minnows. GEORGE E. DREWRY is testing the minimal temperature tolerances of some fishes for his masters thesis.

WILLIAM C. RENFRO has completed his masters degree and is now employed by the Texas Game and Fish Commission. His thesis study was on the distribution of fishes in the Aransas River.

Texas A. and M. College DR. W. B. DAVIS and JAMES R. DIXON are in process of describing a new species of *Coleonyx (elegans-mitratus)* group from the Big Bend region of Texas. DIXON has completed a review of the long-tailed group of the glossy snake *Arizona*. DR. DAVIS is continuing his study of the herpetofauna of the Mexican state of Guerrero.

CHARLES M. FUGLER (Biology Department) started his doctoral studies in herpetology at Texas A. and M. College last September. Most of his work has been concerned with the herpetofauna of Mexico and Central America on which he has authored or coauthored six papers. FUGLER attended Tulane, L.S.U., and the University of Kansas in previous years. His research plans for the summer of 1958 include an expedition to British Honduras.

Seventeen students enrolled for the spring course in herpetology taught by DR. RICHARD J. BALDAUF. The class joined the Texas Herpetological Society at its meeting near Laredo, Texas in March.

Contractual research on fish mortality at state hatcheries is being done for the Game and Fish Commission of Texas by the Department of Wildlife Management. DR. RICHARD J. BALDAUF and DR. ALVIN PETERS are conducting studies on the biology and control of trematodes, cestodes, and water molds and their effect on fish production and mortality.

WALTER V. ROBERTSON is studying the osteology of *Breevoortia patronus* and *B. gunteri* for his Master's thesis.

#### Texas Herpetological Society

THE TEXAS HERPETOLOGICAL SOCIETY held its annual field meet in the lower Rio Grande valley 40 miles NW of Laredo, Webb County, Texas, on March 15 and 16, with 87 collectors registered. Data compiled so far indicate that at least 10 families, 19 genera, and 29 species and subspecies of reptiles and amphibians were collected. At least ten of the forms represent new records for the county.

New Society officers elected are RICHARD J. BALDAUF (Texas A. and M.), President; ALVIN FLURY (Mathis, Texas), Vice President; JAMES R. DIXON (Texas A. and M.), Secretary-Treasurer; JESSE HAVER (Houston, Texas) and ERNEST TANZER (Texas A. and M.), Executive Board.

#### University of Florida

The following persons, working with ichthyological or herpetological materials, received their Ph.D. degrees recently

at the University of Florida and are now located at the Institutions indicated: DR. WALTER AUFFENBERG is in the Department of Biology of the University of Florida. DR. ARNOLD B. GROBMAN was chairman of his graduate committee. DR. DAVID CALDWELL is with the U. S. Fish and Wildlife Service at Brunswick, Georgia. DR. COLEMAN J. GOIN served as chairman. DR. JOHN CRENSHAW is in the Department of Zoology at Antioch College, Yellow Springs, Ohio. DR. ARCHIE CARR was chairman. DR. RICHARD HIGHTON is in the Department of Zoology at the University of Maryland, College Park. DR. GROBMAN was chairman.

Current doctoral students working on problems with the cold-blooded vertebrates include: RICHARD JOHNSON (DR. CARR, chairman); RAM SETHI (DR. GROBMAN, chairman); CHARLES WHARTON (DR. J. C. DICKINSON, chairman); and DUKE WILDER (DR. GOIN, chairman).

DR. AUFFENBERG, Assistant Professor of Biology, joined the staff in September, 1956. He has previously spent a year at the Museum of Comparative Zoology. Recent summers have been used for vertebrate paleontological work in the West Indies under a National Science Foundation grant.

DR. JOHN C. BRIGGS, Assistant Professor of Biological Sciences, spent the academic year 1957-58 on leave of absence at the Department of Anatomy, School of Medicine, University of Florida. Beginning July 1, 1958, he will assume a new position in the Department of Anatomy, University of British Columbia. At Vancouver, DR. BRIGGS will continue his research on the distribution, behavior, and taxonomy of fishes.

DR. CARR, Professor of Biology, returned to Gainesville in February, 1958, after 18 months of service as technical advisor to the University of Costa Rica. He continued his work on marine turtles supported by grants from the American Philosophical Society and the National Science Foundation. He will spend the summer of 1958 in Costa Rica and South America.

DR. DANIEL M. COHEN, Assistant Professor, joined the staff of the Department of Biology in September, 1957, and received his Ph.D. from Stanford University in January, 1958.

DR. C. J. GOIN, Professor of Biological Sciences, is continuing his work on *Eleutherodactylus* in Jamaica under sponsorship of a grant from the American Philosophical Society. His work on a textbook of herpetology is progressing favorably.

DR. GROBMAN, Director of the Florida State Museum, is serving as ASIH representative on the National Research Council and is a member of the Executive Committee of the AIBS.

DR. JOHN D. KILBY, Associate Professor of Biological Sciences, spent the summer of 1957 at the marine laboratory at Beaufort, N. C.

DR. WILLIAM RIEMER, Assistant Curator at the Florida State Museum, has a Fulbright grant which will take him to Israel for the 1958-59 academic year. He will offer courses in herpetology and zoogeography. He has been making intensive collections in northwest Florida and adjacent states under terms of a National Science Foundation grant. Dr. Riemer is currently serving as Secretary-Treasurer of the ASIH South-eastern Division.

During the past two years, the University of Florida Post-Doctoral Fellowship was held by herpetologists. DR. HERNDON DOWLING, of the Department of Zoology of the University of Arkansas, spent 1956-57 in Gainesville and DR. CARL GANS, who had just completed his work at Harvard University, was in residence for 1957-58.

DR. JOE A. TIHEN, while spending the year 1957-58 in the University of Florida Medical School completing a project on medical genetics with DR. GROBMAN and others, visited the Department frequently in conjunction with his herpetological studies.

DR. JAMES A. BÖHLKE, of the Academy of Natural Sciences of Philadelphia, was in Gainesville and environs in March, 1958, as a Collaborator with the Florida State Museum.

The collections of cold-blooded vertebrates are enjoying substantial growth. The fish collection is especially rich in series of freshwater and marsh fish of Florida. Recent additions include collections of shore and deepwater forms from the Gulf of Mexico as well as from the vicinity of Jamaica. The herpetological collection has had large additions from Jamaica, Costa Rica and the central Gulf Coast area. This latter collection has grown about 30 percent in the last three years and now contains approximately 43,000 specimens. The vertebrate paleontology collections are rich in herpetological material from the Pliocene and Pleistocene of Florida. Although important specimens of large crocodilians and turtles have been obtained, the more promising material is in the form of extensive series of micro-vertebrate fossils. The fish collection is under the curatorship of DR. COHEN; the herpetological collection, DR. RIEMER; and the vertebrate paleontological collection, DR. AUFFENBERG.

The new *Bulletin of the Florida State* inaugurated in January, 1956, has contained more than a half-dozen numbers devoted to cold-blooded vertebrates. DR. RIEMER is editor.

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### Chicago Natural History Museum

Research in the Division of Fishes is concerned with material collected on two cruises, in which LOREN P. WOODS participated, of the M/V OREGON to the western Caribbean and the Guianas and Brazil. WOODS is working on fishes from shallow water and the mid-depths, MARION GREY on those from deep waters, and PEARL SONODA on the scorpaenids. WOODS and DR. HURST SHOEMAKER are studying *Alosa* of the Mississippi and Gulf drainages and would appreciate the loan of any *alabamae* and *ohioensis*. DR. EDWARD M. NELSON continues his work on morphology, with special emphasis lately on the axillary gland of batrachoids and the lateral line nerves of electric fishes.

In the Division of Amphibians and Reptiles, work on 74,943 amphibians (actual count!) from the Parc National de l'Upemba, Belgian Congo, has been completed. The report, a joint effort of the late DR. KARL P. SCHMIDT and of DR. ROBERT F. INGER, will appear in the biological series on the park. DR. INGER will spend three months in the Congo in 1959 and begin the study of another large Congo collection. INGER is also continuing to work on the herpetological fauna of Borneo. HYMEN MARX has been working on the fauna of North Africa and Southwest Asia, with manuscripts on the troublesome genus *Spalerosophis* and on the fauna of northern Iraq now in press. The latter is a joint paper with DR. CHARELS A. REED. GEORGE RABB, now at Brookfield Zoo, is a regular visitor, devoting himself mainly to Central American plethodontids. HAROLD KERSTER, a student at the University of Chicago, has been studying caecilians.

### The American Museum of Natural History

CHARLES BOGERT is preparing a report dealing with the adaptive significance of voice in amphibians. This study is based, in part, on experiments conducted at the Archbold Biological Station, with the assistance of Miss ALICE G. C. GRANDISON, during the summer of 1957. Too, a report is in preparation on the systematic status of toads allied to *Bufo debilis* and research is in progress on the thermal requirements of some of the larger iguanids, including *Amblyrhynchus*, *Conolophis*, *Iguana*, and *Cyclura*. RICHARD BOTHNER is assisting in the study of thermal requirements.

RICHARD ZWEIFEL is completing a study of the populations of *Cnemidophorus* allied to *C. sackeri* in western Mexico. He is planning to study embryonic adaptations to temperature in the Salientia of Arizona during the summer.

SAMUEL McDOWELL is studying the cranial foramina and the morphology of testudinoids.

DR. C. M. BREDER, JR. has been working in Florida on the schooling habits of fishes. Much of the work was carried out at the Cape Haze Laboratory, where DR. EUGENIE CLARK, Director of the Laboratory and Research Associate in the Museum's Department of Animal Behavior, is studying the function of abdominal pores in sharks.

DR. EVELYN SHAW is working on the ontogeny of schooling behavior in cichlid fishes. DR. ARLINE TUCKER is studying modifications of reproductive behavior in cyprinodonts in relation to modifications of the external genital apparatus. DR. LESTER R. ARONSON is studying the effects of castration on reproduction and parental behavior in another cichlid, the blue acara.

The International Game Fish Association is moving its offices from the American Museum of Natural History to Miami, Florida.

### Illinois Natural History Survey

The Illinois Natural History Survey will mark its 100th birthday in 1958.

Originating as the Illinois State Natural History Society and later known as the State Laboratory of Natural History, this state research and service agency acquired its present name in 1917 with the union of the old State Laboratory and the State Entomologist's Office. Throughout the history of the agency, research has covered many diverse phases of zoology and botany, particularly those relating to renewable natural resources of the state.

That the fields of ichthyology and herpetology received their share of attention even in the early days of the agency is evident in the contents of the first volume of published reports: pioneering studies of the fish fauna of Illinois by E. W. NELSON and DAVID STARR JORDAN, several papers on limnology and ecology of fishes by STEPHEN A. FORBES, and a catalogue of the amphibians and reptiles of the eastern United States by NATHAN S. DAVIS and FRANK L. RICE. Other notable contributions to these fields in the early days of the organization were made by such men as THOMAS LARGE, HARRISON GARMAN, H. A. SURFACE, R. E. RICHARDSON, and ROBERT RIDGWAY. Some of the studies, such as DIRECTOR FORBES "The Lake as a Microcosm" and FORBES and RICHARDSON's "The Fishes of Illinois," have become classics in their fields.

In recent years, research in ichthyology and herpetology has been continued by the Illinois Natural History Survey's Section of Aquatic Biology and Section of Faunistic Surveys. The former section, directed by DR. GEORGE W.

BENNETT, is continuing its studies on the Illinois and Mississippi rivers and has expanded its researches to include ponds, artificial and natural lakes, and small rivers. The management of waters for sport fishing has reached a point where further progress will be slow unless and until certain basic information on the dynamics of fish populations is available.

DR. PHILIP W. SMITH of the Section of Faunistic Surveys has recently completed a distributional and variational study of the herpetofauna of Illinois, and with personnel of the Section of Aquatic Biology, is in the preliminary stages of a survey of the present fish fauna of Illinois. In this study, attention will be focused on the changes that have occurred in the 50 years since FORBES and RICHARDSON did their monumental work.

The Natural History Survey's most recent publication on ichthyology, "Ecological Life History of the Warmouth (*Centrarchidae*)," by DR. R. WELDON LARIMORE, received the Wildlife Society's 1957 award as outstanding fish ecology and management publication of the year.

**University of Illinois** DAVID L. LANGEBARTEL is completing a doctoral dissertation on the comparative hyolaryngeal anatomy of snakes. PETE CHRAPLIWY is just getting under way with a study of ecotype plasticity in *Sceloporus jarrovi*. KENNETH WILLIAMS is involved in a study of the herpetofauna of sand dunes in northwestern Mexico. DR. HOBART SMITH is working with: influence of injection site upon symptomatology of snake envenomation; a revision of the checklists of Mexican reptiles and amphibians; and construction of a checklist and key to the herptiles of Panama.

**International Commission on Zoological Nomenclature** MR. FRANCIS HEMMING, who has held the Office of Honorary Secretary to the International Commission on Zoological Nomenclature since 1936, has been told by his medical advisers that he must seek immediate relief from the greater part of his duties and that he ought not to incur the physical strain involved in completing the arrangements for the Colloquium on Zoological Nomenclature to be held in London next July. At the same time Mr. HEMMING intimated that he did not propose to offer himself for reelection as Honorary Secretary.

The International Trust has made arrangements in consultation with SIR GAVIN DE BEER, Director, British Museum (Natural History), and

President of the coming Fifteenth International Congress of Zoology. With the consent of SIR WILLIAM PUGH, Director of the Geological Survey, London, and with the approval of the Department of Scientific and Industrial Research and of H. M. Treasury, MR. R. V. MELVILLE, a senior member of the Palaeontological staff of the Survey, has been released for a period of one year to take immediate charge of the Office of the Commission with the title of "Assistant Secretary to, and Director of the Office of, the International Commission on Zoological Nomenclature". In addition MR. MELVILLE has been appointed Assistant Manager to the Trust. He will take up his new duties on Thursday, May 1, 1958.

MR. MELVILLE's first duty will be to obtain suitable accommodation for the Office of the Commission (which hitherto has been housed rent-free in MR. HEMMING's private residence) and to complete the arrangements for the meeting of the Colloquium on Zoological Nomenclature.

At the request of the Trust and in order to assist MR. MELVILLE to concentrate his attention on the most urgent tasks, MR. HEMMING has consented to see through the press the edition of the *Official Lists* and *Official Indexes* now in the course of being printed and, in addition, to prepare the *Opinions* required to give effect to the decisions already taken by the Commission in a number of cases. MR. HEMMING has also agreed for the time being to retain the position of Managing Director and Secretary of the Trust.

#### Microcards Available

CUVIER AND VALENCIENNES' "Histoire naturelle des poissons" (22 vols. + 650 pls.; standard octavo ed.) is available on microcards for \$30.00. This is the price per set for 15 sets; eleven more must be subscribed before the order can be placed. DR. JOHN C. BRIGGS is generously furnishing his microcard negatives for this reprint. Interested persons should write F. H. BERRY, U. S. Fish and Wildlife Service, P. O. Box 283, Brunswick, Georgia.

#### Omission in Copeia

The review of "Fishes of the Red Sea" published in Copeia No. 2 was prepared by DR. EUGENIE CLARK. Her name was omitted as author.

#### Exchange Request

The Department of Wildlife Management at Texas A. and M. College, College Station, Texas, is interested in exchange

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ing preserved specimens of reptiles, amphibians, and fishes. Forms found in Texas and Mexico will be exchanged for certain U. S. and foreign species. Write WILLIAM B. DAVIS or RICHARD J. BALDAUF for their Want List.

#### News Notes

DR. JAMES OLIVER has been appointed Assistant Director of the

BRONX Zoo.

DR. FRED R. CAGLE will spend forty days in Russia this summer to gain information useful in the translating program of the American Institute of Biological Sciences.

MR. DON BOYER, completing his doctorate at Tulane University, has accepted an appointment to the faculty of Washburn University, Topeka, Kansas.

#### ANNUAL MEETING SOUTHEASTERN DIVISION

The eighth annual meeting was held in conjunction with the meetings of the Association of Southeastern Biologists, at Florida State Uni-

versity, Tallahassee, 17 to 19 April 1958. The following papers were presented during the morning of 18 April.

Delayed hatching in stranded eggs of *Fundulus confluentus*. ROBERT W. HARRINGTON, JR., Florida State Board of Health.

The function of the abdominal pores in elasmobranch fishes. EUGENIE CLARK AND JOHN H. HELLER, Cape Haze Marine Laboratory and New England Institute for Medical Research.

Comments on the barred pattern in the black-barred sheepheads, *Archosargus probatocephalus* and *A. oviceps*. DAVID K. CALDWELL, U.S. Fish and Wildlife Service.

Florida's west coast: a biogeographic puzzle. WILFRED T. NEILL, Research Division, Ross Allen Reptile Institute.

Ecology of the fishes in the streams of the Savannah River Plant area. HARRY W. FREEMAN, University of South Carolina.

Feeding habits of a captive *Leptodeira annulata*. T. P. HAINES, Mercer University.

Preliminary report on the halfbeaks (Hemiramphidae) of the western Atlantic. FREDERICK H. BERRY, U.S. Fish and Wildlife Service.

New distribution records of freshwater fishes in western Florida. RALPH W. YERGER, Florida State University.

Burrowing modifications in the lizard *Rhineura*. CARL GANS, University of Florida.

Field trips were conducted to St. Marks Wildlife Refuge and Alligator Harbor Marine Laboratory on 19 April.

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The American Society of Ichthyologists and Herpetologists is a member of the American Institute of Biological Sciences and of the Division of Biology and Agriculture, National Research Council, and is an affiliate of the American Association for the Advancement of Science. An annual contribution is made to the publication of the Zoological Record.

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